THE SOCIETY OF

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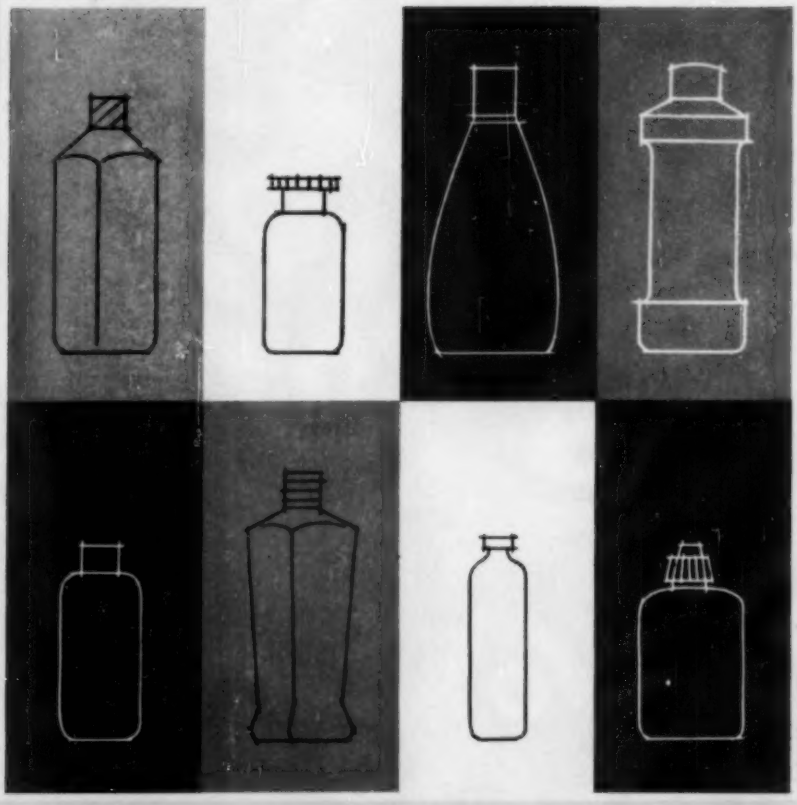
POLYOLEFINS LOOK FOR MORE CONTAINER APPLICATIONS

(see page 21)



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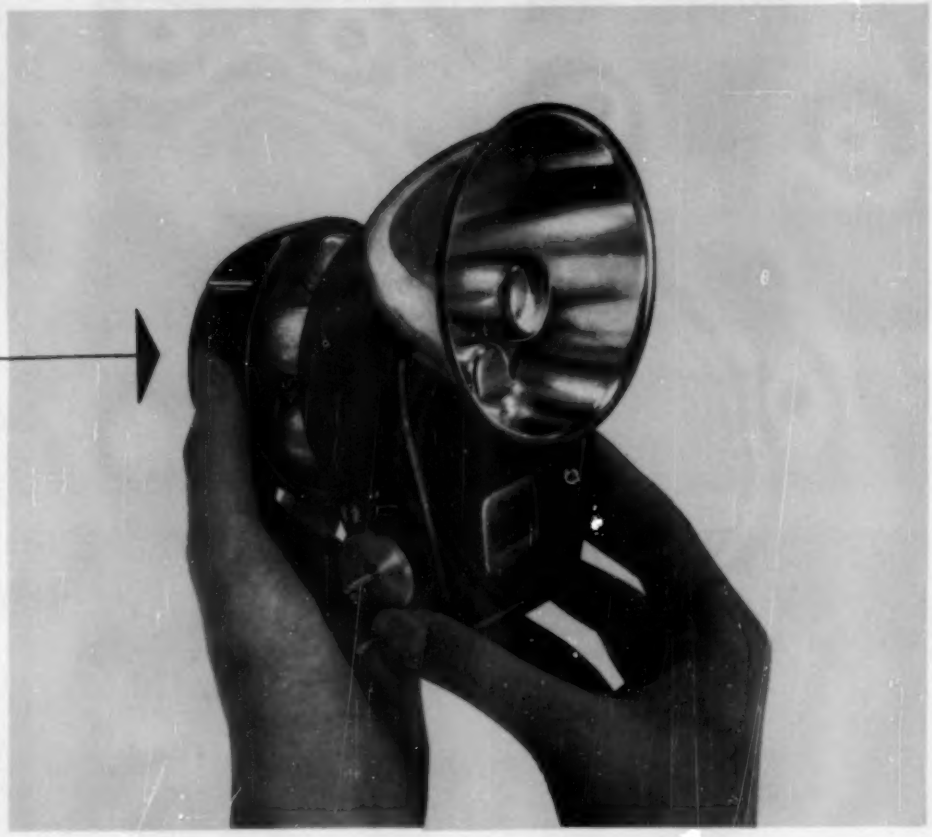
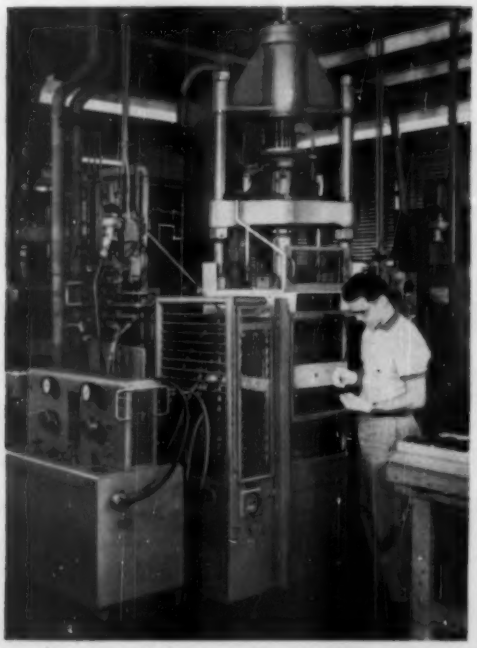


Kodak's Flasholder features a 6-shot bulb magazine which, when rotated brings a fresh bulb into position. It is molded of thermoplastic in a two-cavity mold.

Turrets for new Kodak Flasholders injection molded on Watson-Stillman machine



You might be one of thousands of camera fans who own a new Kodak Rotary Flasholder. If so, you've gotten a close look at a nice piece of injection molding.

The turret-type bulb magazines for these flashguns are injection-molded at Kodak on a Watson-Stillman 6-ounce vertical machine. It delivers precise, uniform-quality molding that easily meets Kodak's high requirements — plus the volume and economy so necessary in a product of this type.

Watson-Stillman equipment has been used at Kodak's Apparatus and Optical Division for over five years. Their experience is typical of the many molders throughout the country, using Watson-Stillman machines.

Write for full details on Watson-Stillman injection molding machines. Capacities range from 5 to 500 ounces.

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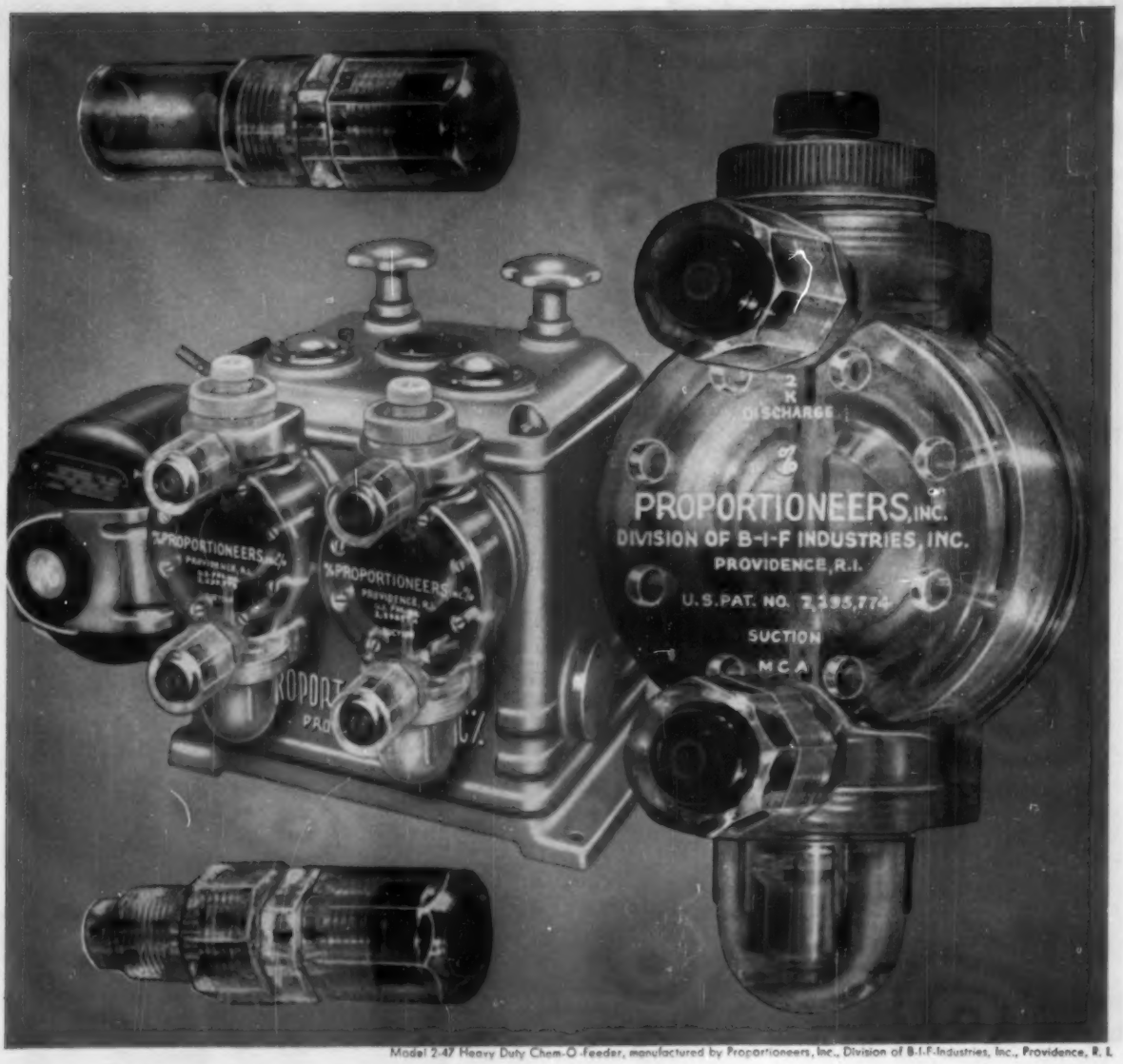

Model 2-47 Heavy Duty Chem-O-Feeder, manufactured by Proportioneers, Inc., Division of B-I-F Industries, Inc., Providence, R. I.

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"Dish-Quick" all purpose spray and dishwasher made by Modern Faucet Mfg. Co., Los Angeles, California, uses hose made by Extruded Products Division, Stillman Rubber Company, Fullerton, California. Hose has synthetic rubber inner lining, nylon cord, and Geon polyvinyl jacket. B.F.Goodrich Chemical Company supplies the Geon polyvinyl materials only.

Geon jacket insulates faucet hose against kitchen corrosion

Who'd guess that a kitchen sink would be a tough place for rubber hose to perform? Experience proves that kitchen chemicals and grease will decompose a conventional rubber hose. The problem was solved with a jacket made from Geon polyvinyl materials.

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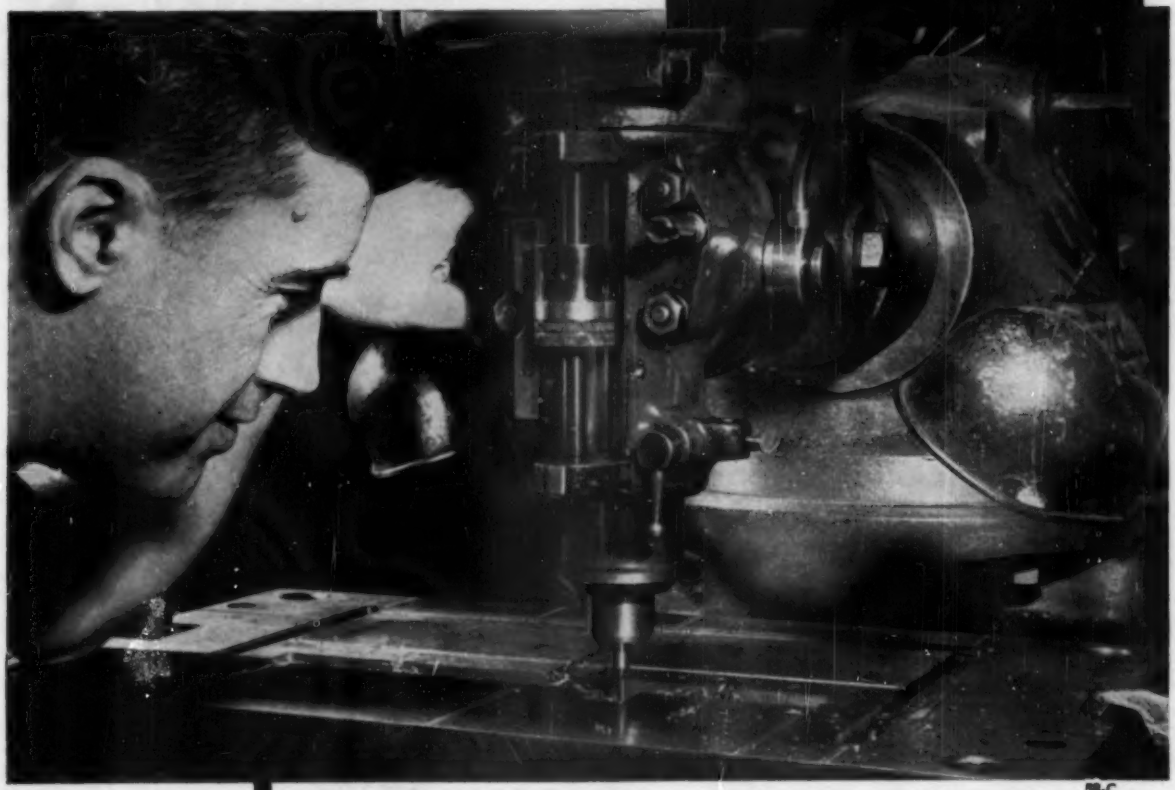

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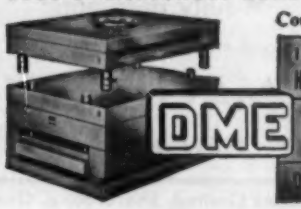

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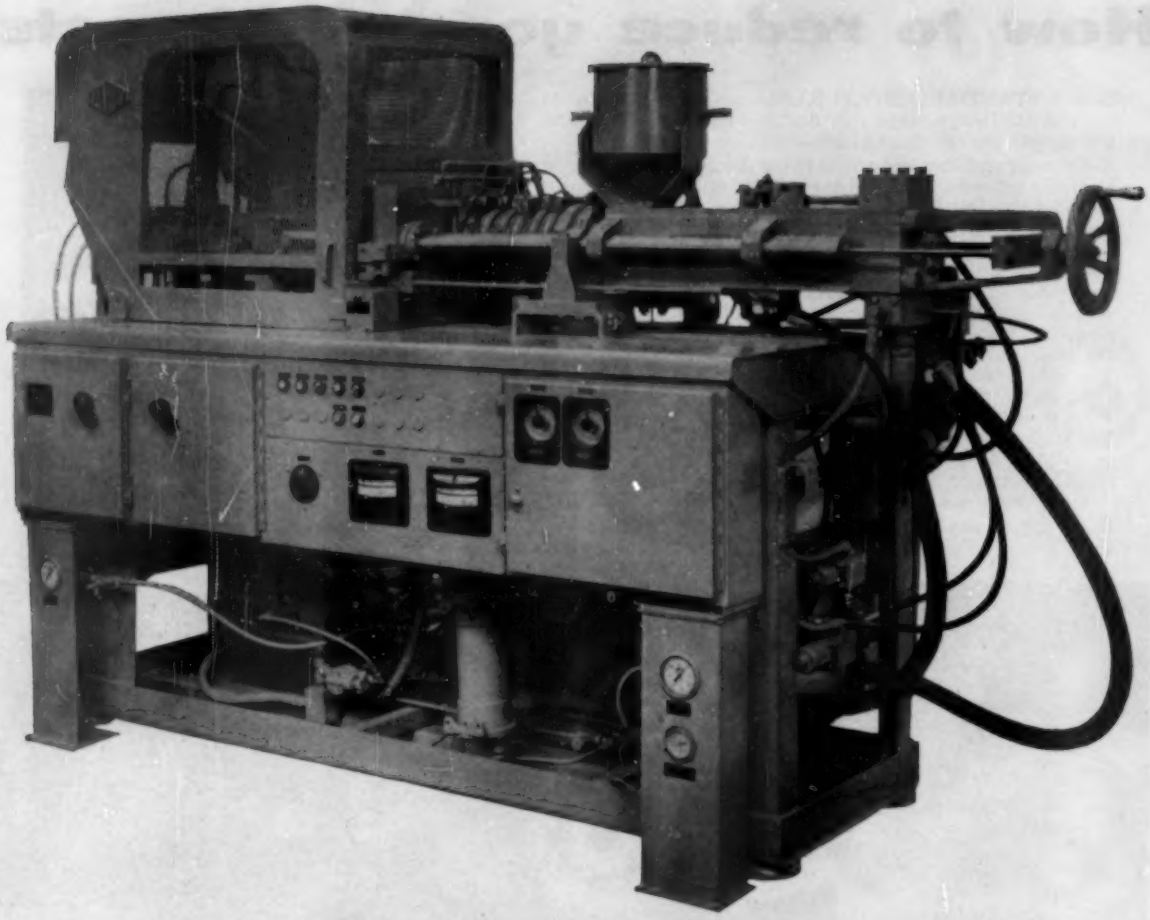

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Charles E. Rhine
Editor

EDITOR'S NOTEBOOK

HAVING MOLDING PROBLEMS?

— let the SPE Journal help you

Nearly every day you are confronted with problems of design and production on which you would welcome the advice of an experienced person. Sometimes you may have difficulties with unfamiliar situations, or you may simply wish to have explained some fundamental point of practice or definition. You can now bring these problems to the *Journal* for a solution. We will provide a *free* consulting service to anyone having questions concerning plastics molding. This service will be conducted by Louis Paggi, Consultant for Du Pont and Editor of Molding Cycles, a monthly feature of the *Journal*.

All questions sent in will be reviewed by Mr. Paggi and other eminent authorities, and the answers will be printed in the *Journal* along with the original question. Mr. Paggi will publish this question-and-answer forum each month in Molding Cycles beginning with the January 1959 issue.

We believe that those of you who are continually faced with the task of solving problems in the molding shop will find this new treatment of our Molding Cycles feature a valuable aid to you in your everyday work. By reviewing this feature each month you can keep abreast of new techniques in the field, and see how others are solving problems which may also be troubling you.

To take advantage of this new service offered by the *Journal*, send your questions to Louis Paggi, Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours and Co., Inc., Wilmington 98, Delaware. Your name will be withheld from publication if you so request.

Are you hiding your light under a bushel?

In visiting the Sections I have come across a number of members who say to me, "I have an idea for a *Journal* article," and then go on to explain about some really interesting work in plastics engineering or some novel idea for achieving economies in production. And I have come to realize that there are many members who have stories to tell and either they don't know that we want these for the *Journal*, or they don't know how to go about getting them published.

Actually, the *Journal* editorial pages are here for you to use. Its primary purpose is to provide you with a medium for telling others of your work. So why not take advantage of it? Just send me a note outlining your ideas for a technical paper. If it looks promising, you'll soon get a go-ahead.

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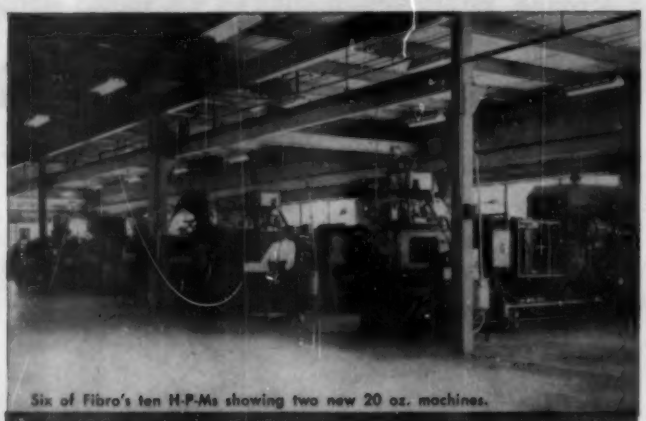
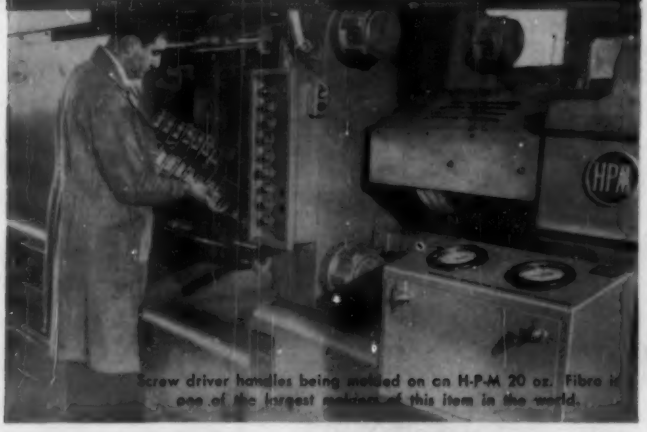


Six of Fibro's ten H-P-Ms showing two new 20 oz. machines.

One of two H-P-M 6 oz. machines molding closures—fully automatic.



Screw driver handles being molded on an H-P-M 20 oz. Fibro is one of the largest molders of this item in the world.

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To keep brand loyalty such as this, these H-P-Ms just had to be better—in every way for ten years. In fact, John Fontenelli, general manager of FIBRO, says, "We buy H-P-Ms because of their ability to provide capacities over and above their normal rating. Then, too, they are built to withstand our 24 hours a day, seven days a week production schedule."

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More units per foot of nylon rod—that's one of the many benefits Charles DeMartin (third from left), President of General Screw Products, got by switching to the new, longer Danco Rod made of Spencer Nylon. Finished nylon part is used in lens carriage assembly of a Haloid Xerox® photocopying machine.

Leading user of nylon rod reports:

150% Less Handling...5% Less Bar-End Loss

How new 10-foot Danco Rods made of Spencer Nylon help General Screw Products turn out more parts at less cost:

"Bigger and better" may be general terms, but they apply perfectly to the new 10-foot nylon rod now being marketed by Danielson Manufacturing Company of Danielson, Conn. Using Spencer Nylon, the Danielson Company has developed a nylon rod that is 2½ times as long as the 4-foot rod other companies produce!

One of the first to cash in on the many advantages offered by the new Danco Rod was General Screw Products of Rochester, N. Y. The 10-foot rod of Spencer Nylon pays off for them three ways:

Since they don't change lengths so often now when machining parts, there is **(1)** less machine down-time, **(2)** less handling, and **(3)** more unit production per man-hour of work. But that's not all!

With more usable work surface per rod, there is less bar-end loss. General Screw Products reports that the Danco Rods of Spencer Nylon give them a saving of one foot of material in every twenty feet used! Also, the rods of Spencer Nylon have proved to have greater tenacity than the rods previously used. The rods have a finish "equal to or better than" the rods formerly used, which General Screw Products had considered to be the best available for their machine operation—until the Danco Rods of Spencer Nylon were developed!

You, too may discover that the special properties of Spencer Nylon make it the ideal plastic for your nylon needs. For complete information, write: Spencer Nylon, Spencer Chemical Company, 600 Dwight Bldg., Kansas City 5, Missouri.

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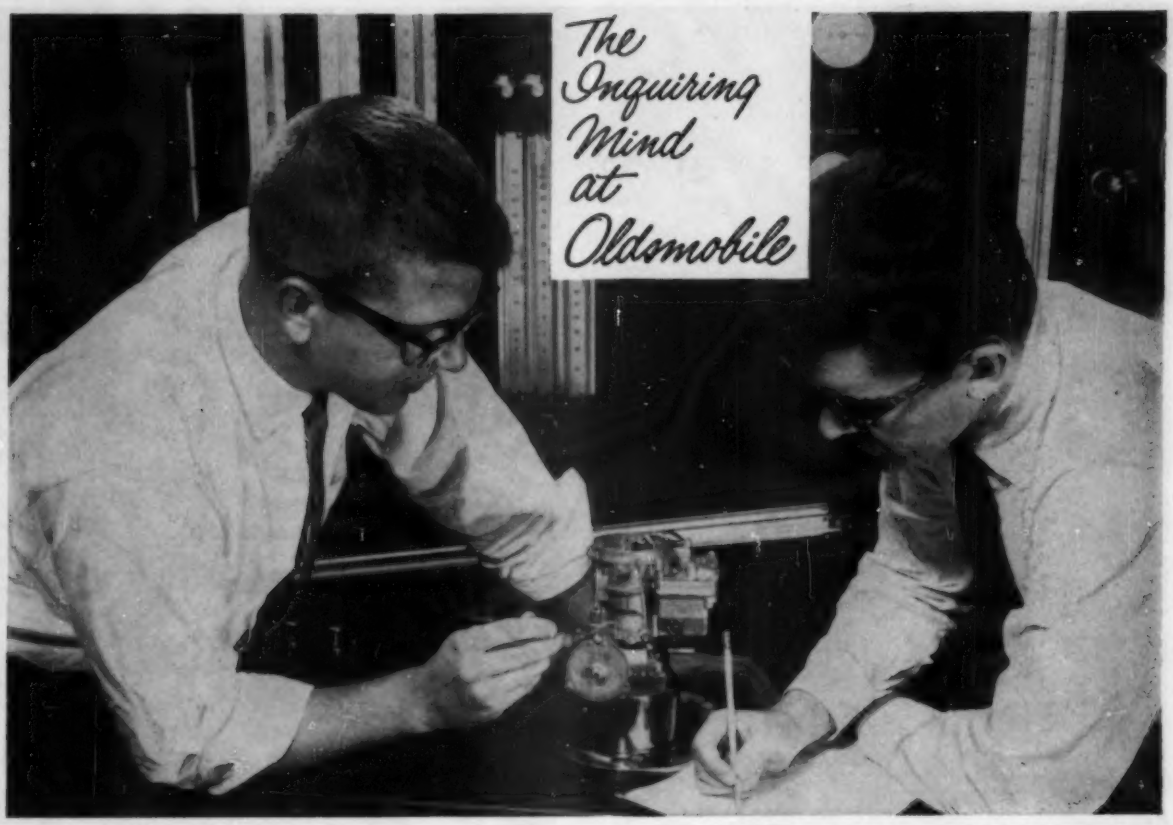

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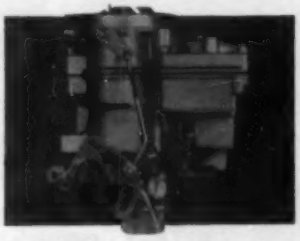
TWO STEPS TO NEW FUEL ECONOMY

Unique Oldsmobile-developed two-stage automatic choke is a major step forward in improving automobile operating economy.

One of the important carburetor developments during the past few years was the automatic choke, a device that allows the automobile to be started in cold weather, and then keeps it running until the engine is sufficiently warmed up to sustain itself. Every automatic choke has two separate functions: 1) choking, which enriches the fuel-air mixture for starting, and 2) the idle speed control, which keeps the engine from stalling once it is started. In the past, and on all present carburetors except those used on the 1959 Oldsmobile, these two functions have operated simultaneously with the result that the engine ran on a rich mixture for the same length of time that the fast idle was "on". This resulted in excess fuel consumption.

With the introduction of the 1959 Oldsmobile, the two functions have been separated with a new and exclusive two-stage automatic choke developed by Oldsmobile engineers. An ingenious system of over-running levers allows the choke fly to open 75% sooner than previously required. The fast idle, however, remains "on" for the full warm-up period so the engine will not stall. This early elimination of the choking function represents a considerable fuel saving in cold weather when numerous short trips are made.



At Oldsmobile the Inquiring Mind is always at work, finding new and better ways to design, engineer and build finer automobiles for the most discriminating of buyers—the Oldsmobile owner. Discover the difference for yourself by visiting your local Oldsmobile Quality Dealer and taking a demonstration ride in a 1959 Oldsmobile.

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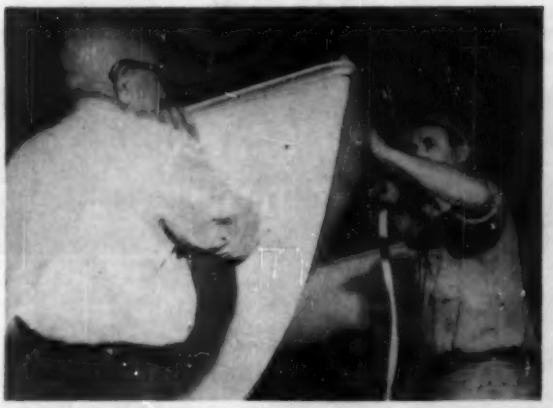

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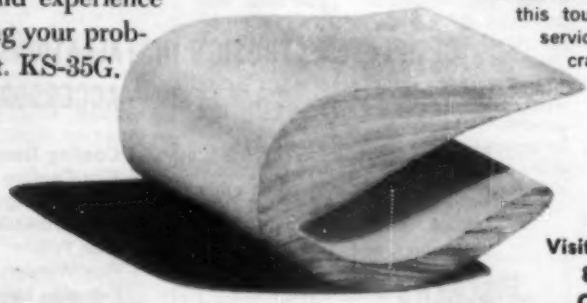

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U.S.I. POLYETHYLENE NEWS
A series for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

Packaging Notes

New Shock-proof Package has been developed for dropping medical supplies by air without the use of parachutes. The package features a flexible tube of polyethylene twist-suspended inside a fiber case by means of rings attached to the case. In addition to drop tests, the package has been subjected to water-spray and other tests.

Although developed primarily as a drop case for military and disaster use, the package has attracted the attention of electronic tube manufacturers and instrument makers as a replacement for the more costly and less safe packaging now in use.

Polyethylene and Steel Returnable Container for the shipment of corrosive chemicals is now being marketed. The container features a polyethylene inner container with a steel drum outer jacket. Compared with conventional glass carboys, the new container is claimed to have a lower package cost, lower tare weight, and less cubage . . . with consequent savings in freight and handling costs. Container is being made in two sizes: standard weight 14 gallon with 5¾ pound inner container, and the heavy-duty 13 gallon with 8¾ pound inner container.

Polyethylene Zippers are being used on filter cloth bags. The zippers are jam-proof and corrosion-resistant. The poly zipper strip is sewn to the cloth with a special stitch that prevents leaking. Zippers ride in smooth grooves with no teeth to snag or collect dirt. Closure is said to withstand 80-pound pull.

Self-venting Poly Closures for Drums eliminate the need for separate vents on containers used to ship liquids. The venting feature is an improvement on the retractable polyethylene spout familiar to users of liquid chemicals in metal drums.

The improved spout prevents liquid surge or "glug" in pouring. It is claimed that there is no waste or spillage, since the closure will vent in any pouring position. The polyethylene cap for the new spout also features a small bail to facilitate pulling the spout up into pouring position.

Self-venting flexible spout pours easily from any position. Picture shows spout being raised into pouring position via new bail on reseal cap.

New Petrothene® Shut-down Resin Solves Problem of Post-startup Rejects

Eliminates High Temperature Degradation of Resin Left in Machine

A special shut-down resin is being made available as a service to customers by U.S.I. Intended for use immediately before shut-down, this material is designed to prevent the high temperature degradation that is usually encountered in polyethylene processing equipment during normal shut-down and start-up procedures.

When a machine operating on conventional resin shuts down, the product immediately after start-up is usually unsatisfactory. Gels, fisheyes, discolored particles, and other evidences of resin deterioration show up, not only in the initial production, but sometimes for hours afterward. The reason: Resin in some parts of the machine is held too long at too high a temperature. Thermal degradation results.

Adding Petrothene 205-1 to purge the production resin from the machine just prior to shut-down eliminates usual waste at start-up.

U.S.I.'s answer to the problem is PETROTHENE 205-1, a specially prepared resin that will withstand prolonged exposure to high temperature. When this material is in the machine during normal cooling and heating periods before and after shut-down, minimum thermal degradation takes place.

The technique for using the resin is simple. A few minutes before shut-down the special resin is fed to the machine. When the normal resin has been purged, the machine can be shut down. There is little or no waste and no after effect in the machine when the new resin is used.

PETROTHENE 205-1 is supplied in pellet form, packed in 50-lb. bags. Full details about this special shut-down resin may be obtained by contacting your nearest U.S.I. office.

New Resin for Poly Pipe Wins NSF Approval Seal

A new U.S.I. polyethylene resin — "Petrothene" 102-216 — has been given the National Sanitation Foundation Seal of Approval for use in potable water supply pipe. Pipe made with the new resin has given outstanding results in tests conducted at U.S.I.'s Research and Development Laboratory. Minimum quick burst pressure was 15 to 20% above the minimum required under the Department of Commerce specification CS197-57. No failures were encountered in the slow burst test or in 96 hours of stress crack testing. Information on this resin and other NSF-approved PETROTHENE resins may be obtained from your nearest U.S.I. office.

Visit U.S.I. in Booth 501, Nat'l Plastics Exposition

Quality control as a joint responsibility of the resin supplier and his customer is the theme of U.S.I.'s exhibit this year. "Live" tests on resins, laminates, molded and extruded items are highlighted. A special feature is an information booth manned by U.S.I. technical service men to answer questions on polyethylene production and application problems. Be sure to visit U.S.I. in Booth 501!

Polyethylene plus Glass Fiber Yields New Basic Film Material

Polyethylene is now being reinforced with glass fiber to produce a new film that combines the advantages of both these materials. The film, reinforced with non-woven glass fabric, is at present being made in a range of gauges and in clear and black.

Glass fiber reinforcement gives dimensional stability to the film, so that it does not stretch or billow. It also increases the film's break, burst, and tear strengths, which gives the film longer life in rugged applications and makes possible the use of thinner films. Four-mil reinforced film is said to more than do the job of 6-mil unreinforced film.

Other advantages cited include easier repair because any tears or rips are localized, easier heat sealing because films are thinner, higher grommet strength, and low cost.

DO YOU HAVE a new polyethylene packaging development you'd like the industry to know about? Make it routine to send your information on new developments to U.S.I. POLYETHYLENE NEWS.

Address the Editor,
U.S.I. POLYETHYLENE NEWS, U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corp., 99 Park Avenue, New York 16, N. Y.

U.S.I.

Vol. III No. 5

POLYETHYLENE PROCESSING TIPS

HOW TO MINIMIZE NECK-IN IN EXTRUSION COATING AND FLAT-FILM CASTING

Extrusion coaters and film makers working with polyethylene are frequently faced with the costly and bothersome problem of "neck-in" during draw-down of the hot melt web between the die and the nip or casting roll.

It is accompanied by "beading," or thickening of the melt at both edges of the coating or cast web. As the roll is wound up, the weight of the coated sheet or film is supported by the two beads. This results in a soft roll, sagging in the middle, or in possible breaks in the taut edges of the substrate. Excessive neck-in means trimming the edges of the sheet, with a considerable loss of usable web width and material.

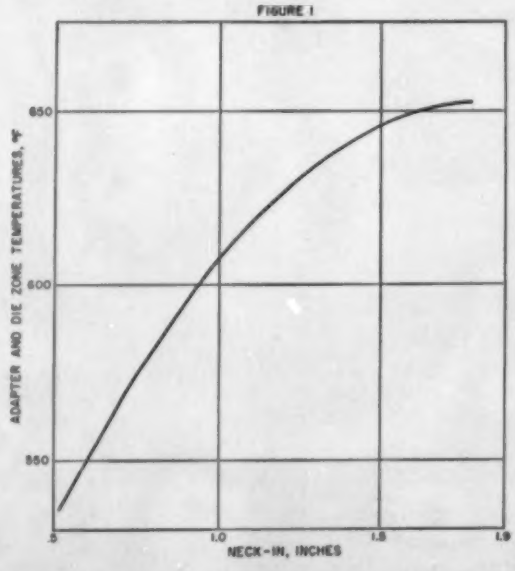
Because of the interest in minimizing neck-in and beading, the Technical Service Laboratory of U.S.I. has carried out research on this condition. The work has established that neck-in is dependent on both machine conditions and basic resin properties. It has also established a number of steps which can be taken to reduce neck-in.

Machine Conditions Which Reduce Neck-In

Neck-in is mainly a function of three machine variables—draw-down distance between die lips and chill roll, die setting and die zone temperature.

In flat-film casting, neck-in decreases rapidly as draw-down distance decreases—roughly ¼ in. per inch of draw-down distance.

FIGURE 1



Neck-in decreases as the die setting decreases. In one instance, U.S.I. engineers found that average neck-in decreased by 0.4 in. as the die setting was decreased from 20 to 10 mil, all other conditions remaining equal.

Neck-in also decreases when adapter and die zone temperatures are kept low compared with barrel zone temperatures. Figure 1 illustrates this effect. In this test the average barrel zone temperature was kept constant at 607°F. When adapter melt temperature was lowered from 607° to 550°F, neck-in on each side decreased roughly from 1.0 to 0.6 in.

Resin Conditions Which Reduce Neck-In

U.S.I. engineers have found that neck-in increases with density and the logarithm of the melt index. As melt index increases, average molecular weight decreases. The resin becomes less viscous and has a greater tendency to neck-in at the sides during draw-down. For this reason, temperatures at both ends of the die are often kept lower than at its center.

Minimizing Neck-In Is Often Difficult

Machine conditions and resin properties which reduce neck-in cannot always be utilized fully because they may affect other essential properties or economy adversely. A few examples follow:

- While comparatively *low* adapter and die temperatures have a reducing influence on neck-in, good adhesion to the substrate depends primarily on *high* stock temperatures.

- And while neck-in can be considerably reduced by using a polyethylene of *lower* density, *higher* density improves moisture resistance, impermeability to oxygen, chemical resistance, stiffness, strength and other properties which may be essential.

- A combination of low density and low melt index will result in minimum neck-in, but unfortunately there is an optimum combination below which voids in the hot web will occur at high operating speeds.

It is obvious that neck-in is not an easy problem to solve, and must be dealt with on a compromise basis. U.S.I. Technical Service engineers are available at all times to work with extruders toward minimizing this troublesome condition.

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PLASTICS ENGINEERS JOURNAL

Volume 14, Number 11, November, 1958

POLYOLEFINS look for more CONTAINER applications

Blown and injection-molded containers are gaining advantages over glass and metal on the grounds of performance, economy and merchandising appeal.

W. O. Bracken
Technical Service
Hercules Powder Co.

THE PHYSICAL and chemical properties of high density polyethylene and polypropylene indicate they are worthy candidates for container usage (Table I). Low density, chemical inertness, ability to mold with thin walls, resistance to heat and cold, translucency or transparency, suitability for contact with foods and selective impermeability are among key properties suggesting broad areas of application in packaging food, soaps, detergents, household chemicals, cosmetics, pharmaceuticals and toilet preparations.

This paper was presented at the Regional Technical Conference sponsored by the Western New England Section of SPE.

High Density Polyethylene

High density polyethylene has commercial acceptance in such areas as nursing bottles, syrup dispersers, shampoo packages, lipstick holders, detergent dispensers, deodorant containers and hair waving compounds. The major considerations in selecting this unique polymer (by this we mean the only commercially available plastics with a 250-300,000 average molecular weight and density of 0.945) for the above uses generally encompassed one or more of the following: economical-weight container, freedom from environmental stress cracking, translucency, temperature, and chemical resistance.

Looking at the foregoing requirements in more detail: a nursing bottle was blow-molded with a 38% reduction in weight and, in addition, a 25% lowering of material cost compared with low density polyethylene previously used. Added benefits were heat sterilizability and greater translucency.

Another advance in packaging is the utilization of high density polyethylene as a "carrier" container rather than as solely a functional "squeeze-bottle" package. In other words, the economies of the package must tie in

with its performance to assure market acceptability. Such a development is typified by the recent adoption of a 0.945 density polyethylene container by a toilet preparations manufacturer for packaging shampoo. (Fig. 1). While the general characteristics of the high density polyethylene are similar to the regular polyethylenes, there are some important differences.

1. Greater rigidity allows the use of thinner-walled bottles with corresponding lighter weights, important from a cost standpoint. For example, the plastics bottle mentioned above (Fig. 1) weighs 24 gm. or approximately 1/12 of the empty 16 oz. glass container. Also, with proper design, high density polyethylene bottles can be produced varying from rigid packages to those having enough flexibility to allow use as dispenser, controlled dropper, or in some instances spray packages.

2. Permeation values are appreciably lower for all liquids tested. Usually, a high density polyethylene container will cut down liquid permeation by 1/3 to ½ compared to the low density polyethylene.

3. Significantly higher resistance to heat permits hot-filling of containers or sterilization of empty or loose-capped bottles.

Other factors played an important role in the selection of a plastics for this use. Extensive testing proved the material had the necessary consistency of quality and environmental stress crack resistance. Also, the resin's relative impermeability is a sound indication for obtaining the satisfactory two years' shelf life specified by the manufacturer. The greater rigidity of the material permitted production of a container lighter in weight than previously possible. Additionally, the color fidelity provided a pharmaceutical-type white believed important for professional use of a medicated shampoo. The reduced bulk of the container was another desirable feature, since it conserved valuable shelf space. Despite its light weight, the new bottle readily adapted itself to conventional speeds on the established capping and filling lines. The unbreakability of the bottle led to use of a lower test board and reduction in number of protecting parts in the shipping carton. This same rugged-

Figure 1. A 0.945 density polyethylene container for packaging shampoo weighed only 1/12 that of the glass bottle previously used for this application.

TABLE I

Physical Properties of Polyolefins

Properties	Units	ASTM Method	0.945 Density Polyethylene[a]	Polypropylene[b]
Crystalline Melting Point	°F	D792-50	262	333
Specific Volume	cu.in./lb.	"	29.5	30.9
Molded Density	grams/cc.	"	0.945	0.901
Tensile Modulus, 23°C	lb./sq.in.	D638-52T	125,000	170,000
		0.2 in./min.		5,000
Tensile Yield Stress, 23°C	lb./sq.in.	"	4,400	11-15
Elongation of Yield, 23°C	%	"	20	
Ultimate Elongation, 23°C	%	"	100-700	>220
Stiffness in Flexure	lb./sq.in.	D747-50	135,000	175,000
Impact Strength—Izod				
Notched 23°C	ft.-lb./in.notch	D256-54T	5.5	1
Unnotched 23°C	ft.-lb./in.	"	>32	>32
Notched —40°C	ft.-lb./in.notch	"	1.4	0.2-0.3
Unnotched —40°C	ft.-lb./in.	"	>32	-
Heat Distortion Temperature				
66 psi	°F	D648-45T	172	221
264 psi	°F	"	113	140
Deformation Under Load 122°F				
2,000 psi, 6 hrs.	%	D621-51	10	2.0

[a]These values refer to high density polyethylene produced under the Ziegler license by Hercules Powder Co. under the tradename Hi-fax Type 1600.

[b]These values refer to polypropylene marketed by Hercules Powder Co. under the tradename Pro-fax 6513.

ness of the bottle, together with its lightness provided a substantial safety factor when working with wet or soapy hands.

All told, full scale marketing of this new bottle indicates secure acceptance on the basis of economic and merchandising advantages.

Two additional case histories for high density polyethylene containers may be of interest. A 60 litre and a 28 litre carboy were blow-molded from a mixture of low density polyethylene and high density polyethylene to obtain optimum strength and chemical resistance characteristics (Fig. 2). The larger one was loaded with 130 lbs. of 93% sulfuric acid and the smaller with 80 lbs. of 56% glacial acetic acid. The two carboys were weighed, placed on commercial trucks travelling over the Northeastern United States, subjected to normal unloading and loading handling for a period totalling 8 months from September to May. The heavy chemicals distributor reported no change in the tare weight of the package. The sulfuric acid seemed slightly discolored ("no greater than normally experienced in tests of polyethylene as a sulfuric acid container"). The acid was considered suitable for general commercial use but unsuitable for electrolyte acid, dairy testing acids or for special requirements for water-white acid. The glacial acetic acid remained clear, showed no change in weight and met specifications. We believe that this high density polyethylene material in carboy form or as liner material for metal drums or fiber board containers would prove suitable and economical for transporting muriatic acid, water-white muriatic acid, 56% acetic acid, aluminum chloride, 26° Baume aqua ammonia, 85% formic acid, brines and the like. Also, in view of the higher heat resistance and greater chemical resistance of the high density polyethylene, we believe a broader range of chemicals than is now the case will be packaged in plastics.

Another industrial container in high density polyethylene, injection-molded, is an automotive windshield washer solution holder. Pertinent factors leading to this usage were: savings in space underneath the hood compared with requirements of a glass bottle, impact resistance, freedom from breakage in the event the solution freezes, chemical resistance, and cost savings through integrally molding bosses on the outside container wall to permit rapid installation of the part on brackets mounted on the fire-wall. The cover of this container is also molded of high density polyethylene. Ability to mold this complicated part out of the same material as the base, contributed to the over-all economy of the item.

Polypropylene

Polypropylene has a combination of properties which should complement and extend those markets opened up by high density polyethylenes. These characteristics are higher tensile strength, greater transparency, significantly more heat resistance and a high degree of chemical resistance. The stiffness and processability of this plastics has permitted production of containers with thinner walls than has been possible with previously existing materials. To date, experimental runs have been made on blown 4 to 16 oz. bottles, hospital urinals (to withstand repeated sterilization at 265°F), both alcoholic and nonalcoholic beverage containers, and detergent dispensers to mention a few. The complete absence of environmental stress cracking to date in an extensive series of corrosive agents observed with this

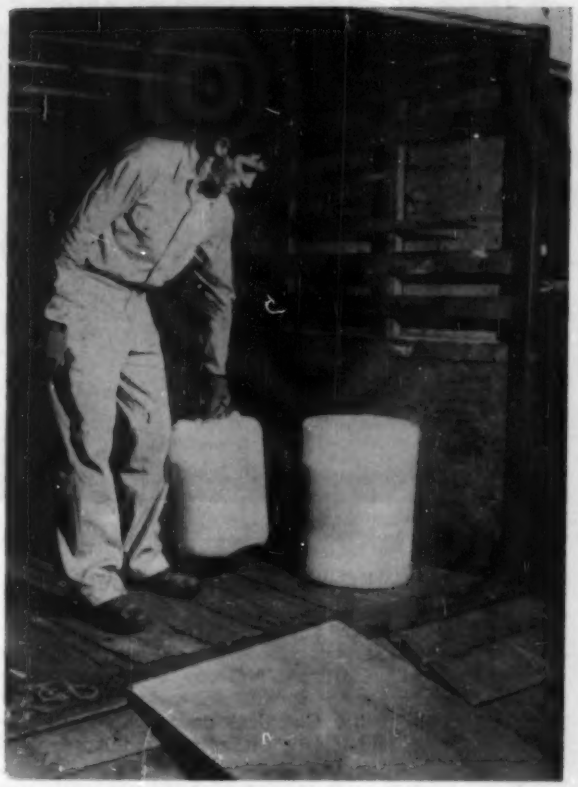

Figure 2. Shipping test for acid carboys blow molded from a mixture of low density and high density polyethylene resins consisted of 8-months handling under actual trucking conditions.

resin is of particular interest to the packaging industry. For example, it has been observed that a severe method for testing environmental stress cracking resistance of a polymer is to run the standard Bell Laboratory test together with such modifications as: changing the concentration of Igepal from 100% to a dilute aqueous 0.5% solution and retain test temperature at 50°C.; change solution to 5% Igepal in water and raise temperature to 90°C.; use distilled water as stress cracking agent with temperature at 90°C. In every case the exposure period exceeded 2,000 hours when the tests were discontinued. In no instance did failure occur. Another, less tangible, property of polyethylene is its resiliency (even in extremely thin sections), which points towards usage in functional as well as "carrier" packages.

At this early stage of commercial production for polypropylene, we would like to present what we feel is a temporary limitation in blown containers. This restriction ties in with experimental tests wherein such bottles, when filled with ice water, will crack when dropped from a height of several feet. However, development work already has shown that annealing, alloying and modification of the extrusion-blowing step made considerable improvement in this property.

We would also like to point out that while Food & Drug Administration qualified stabilizers are used with food-grade types, and that Hercules Power Co. is cooperating with them to obtain their sanction for use of its polypropylene resins in contact with food, this concurrence is not official at the present time. We would like to make clear, however, that it is our belief that this material is satisfactory for such use.

Figure 3. Containers injection molded from high density polyethylene and polypropylene.

Injection-Molded Containers and Closures

Jars and containers injection-molded from high density polyethylene and polypropylene are being test marketed for packaging drugs and cosmetics, laboratory-ware, disposable cups, sundae dishes and refrigerator containers (Fig. 3). Chemical and temperature resistance (high and low) together with ability to mold in thin-wall sections at fast cycles are bases for interest.

In one experimental run on 2 oz. Automolder injection machine, in a single cavity mold, a sundae dish weighing 8.1 gm. was molded in 6 seconds overall at 2,000 psig, main cylinder temperature 715°F, and rear cylinder 630°F. A MI migh density polyethylene shot in the same equipment weighed 9.8 gm. cycled in seven seconds under the same temperature and pressure conditions. The 12% difference in weight, which is about twice that calculated for difference in density, is probably due to the packing tending of the linear polyethylene in this run.

Another molding, in the case a 7.3 gm. hot drink, disposable cup, was run on a three second cycle at 550°F and normal pressures in an automatically operated custom made injection machine. In both items the wall thicknesses tapered from about 24 to 23 mils.

Finally, another experimental molding of a cosmetic jar in polypropylene may prove of interest. The item was injection molded in two pieces: the body of the container was a double-walled structure which held the product; and the bottom was simply a snap-fitted insert plate, also moulded of the same material. The resultant jar gives the traditional massive appearance of these packages while actually weighing only 8.3 gm., has excellent gloss, and color possibilities.

With regard to closures (and there is an estimated 10 billion of all types used annually), these new polyolefins will compete in areas where some combination of styling, color gloss, chemical resistance, performance in service, and economics point out a logical selection. Certain uses where ureas, polyethylene and polystyrene are now established may prove vulnerable to high density polyethylene and polypropylene. Some general considerations to be evaluated in this development are: ability to dry color; no liner requirement for polypropylene. If we assume that polypropylene, as the more rigid, more resilient and higher priced material of the new polyolefins, will enter the closure field both as a direct replacement in existing molds and as new molds are constructed and designed it will have to offer definite plus points. In competing with compression molded ureas, the advantages in injection-molded polypropylene lie in styling freedom, toughness and lack of liner requirements, thinner wall sections, and transparency. Cost-wise this piece should have about a 30% reduction in wall section (weight), if matched colors are used, or a 20% reduction in weight of the piece if dry coloring is satisfactory. These estimates are based on current prices and the assumption that production costs are comparable. Such a reduction in wall sections, incidentally, would still allow considerable safety factor and in fact appears conservative. Since the present market is estimated at about 5 million pounds annually in this field for ureas, there is an interesting dollars and cents basis for examining present costs of light colored thermoset closures.

In the field of polyethylene closures (toothpaste tube closures alone account for 1 million pounds yearly), polypropylene is being evaluated on the basis of yielding needed stiffness with thinner cross-sections. The incentive to evaluate polypropylene in such a use is due to its ability to retain a tight fit on storage (no creep), does not overturn, does not split or stress crack and has a hard, glossy surface.

The use of polypropylene as a replacement for polystyrene will be on the basis of upgrading the performance of the cap at some sacrifice in cost. In one test case polypropylene molded within tolerances in an aerosol can cover die. On dropping the filled can from a height of several feet in the polystyrene cap, the cover broke on first impact. The polypropylene cap withstood 4-5 falls from the same height before cracking occurred and the closure still was useable and retained its fit. Cost in this case however was about 20% higher for the polyolefin compared with polystyrene.

Blowing Procedure

Techniques and equipment for producing blown items are extensively covered by patents in the USA. There are no commercial units domestically produced for sale in this country. It would be hazardous to guess whether or not tools and methods which are available abroad can be utilized here free of legal complications.

The most widespread technique for blowing is based on extruded tubing. Injection molded parisons for subsequent blow forming or injection molded halves which are later heat-, solvent-, or spin-welded are other less widely used techniques.

The extrusion operation can be set up to produce, simultaneously, a number of tubes feeding an equal number of molds. These molds can consist of different shapes, so that potentially the economies of large scale operation can be attained on a number of relatively small runs. In line with this multiple extrusion development there is reported the approaching practicality of an extrusion machine capable of handling as many as four colors at the same time.

Depending upon the size of the extruder, production of blown containers may range from 50 to 350 pounds per hour, and the blown items may range in volume capacity from extremely small items to 15-gal. containers. With the number of pieces per machine amounting to as much as 4,000/hour (depending upon size of blown unit and of machine) it can be readily understood that major emphasis is now being placed upon operational efficiencies. These goals include fully automatic trimming, cleaning (reaming bore to size where required), inspection, surface pretreatment, printing, final inspection, counting and packaging.

A generalized version for an extrusion blowing operation is given below. There are many refinements and modifications described in patent literature in addition to this oversimplified description. The procedure, briefly, involves setting up an extruder (either crosshead or straightaway) arranged so that the tube is extruded downward. This has the two advantages of eliminating the problem of non-uniformity of wall thickness usually encountered with horizontal extrusion and allowing the blowing molds to rotate horizontally. The tube is led between the halves of an open mold. When the lead end of the tube extends a little beyond the mold, the mold closes, pinching the tube together at both ends in the mold. Simultaneously, a knife cuts the tube a short distance from the mold. The closed mold then swings to the second station bringing another open mold into position to receive the next section of the tube for the succeeding bottle. At the second station a needle pierces the plastics tube and sufficient air is introduced to blow the hot plastics against the mold to produce the desired shape. The plastics is then cooled and finally ejected at the last station. The extruder operation may be intermittent or continuous and the number of molds may vary from one to more than a dozen depending upon production volume requirements.

Wall section of the bottle is controlled by the wall thickness of the extruded tube which is in turn controlled by the mandrel used in the extruded head. Wall thickness and weight can be reduced by about 40% while still maintaining greater rigidity by using high density polyethylene compared with low density polyethylene. In the case of a bottle weighing 44 gm, with low density polyethylene, for example, 10-1/3 bottles/pound are produced which at 35¢/pound equals 3.4¢/bottle. A high density polyethylene bottle weighing 27 grams yields 17 bottles per pound and at 43¢/pound is equivalent to 2.53¢/bottle. Faster cycles add to this economy. Temperatures on the extruder head run about 350°F for high density polyethylene and low density polyethylene can be extruded about 320°F. The blowing molds can be run hot or cold but less shrinkage is obtained with cold molds. Shrinkage of bottles is important for accurate measure of contents and to insure proper fit of closures.

When the bottle is ejected, it is necessary to remove the plastics slug from the bottom and saw off the neck. In some cases the neck is purposely blown slightly undersized and then hot reamed. This gives a smoother surface and provides accurate size for insert fitments.

The ability to vary the weight of a given container by resorting to minor modification in equipment and technique has important economic significance. At times, material can be packaged simply by adjusted increase in wall thickness to reduce permeation or increase structural strength sufficiently to meet shelf-life requirements. A case could be made in this regard conceivably for CO_2 or N_2 aerosol containers. Conversely, where the physical and chemical characteristics provide an excessive safety factor, wall section and over-all weight can be reduced to produce a more competitively priced package. Typical instances have been mentioned previously; nursing bottles, and detergent containers.

An illustration of versatility in bottle weights is given by the following laboratory data obtained with high density polyethylene in blowing 4-ounce Boston rounds on a 1-1/2 inch extruder. Weights were varied by adjusting the annular opening for the tube.

Melt Index	Bottle Weight	Wall Thickness	Barrel Temp.	Die Temp.	Blowing Pressure
	Grams	Mils	°F	°F	psi
0.22	8	15-18	370	370	35
0.22	9½	22-24	370	370	35
0.22	13	30-35	370	370	35
0.15	10½	25-27	370	350	45
*	17½	35-45	350	290	30

*High pressure polyethylene

An English blow molding unit furnished by the Granbull Tool Co., Ltd. is designed to be used in conjunction with injection molding equipment. A blow stick is used as an insert with a parison mold. The item is removed from the injection mold and placed in a blowing fixture and blown to the desired size. This dispenses with the cost of the extruder but presupposes the existence and availability of an injection machine. Their literature mentions a 20 second cycle (compared with 3-10 seconds possible with extrusion blowing) and handling of the mold may be done manually or automatically. The bottle is complete when removed from the blowing fixture obviating the finishing operation of sawing and reaming necessary with extruded blow-molded bottles. For small runs and intricate shapes, injection blow molding may have some advantages.

Summary and Forecast

High density polyethylene has enabled plastics bottle manufacturers to produce containers competitively priced with glass and metal. On the basis of economy, performance and merchandising advantages, suppliers of these packages are now aggressively working to capture a share of the "carrier" package market currently held by glass, metal and paper.

For the future, it appears certain that established container manufacturers, both large and small, will explore extensively the possibilities of adding plastics packages to their line. This move seems compulsory from both a defensive and offensive viewpoint. Encouraging this trend are such factors as growing consumer acceptance of plastics containers, increasing interest in larger carriers and the unfavorable cost

(*Continued on page 28*)

Packaging Machinery Advances For Polyethylene Films

Automatic packaging equipment, heretofore available only for paper or cellophane, now can handle the new polyethylene films, turning out attractively-wrapped packages at economical speeds. Here are some of the developments announced within the last few months.

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MANY COMPLAINTS have been voiced in the last year that the manufacturers of packaging machinery have not kept up with the development of new packaging films. Within the last six months this statement, when used in conjunction with polyethylene film, has been false, according to package machinery manufacturers. Packaging with film from polyethylene resins can now be accomplished at economical speeds and results in highly attractive packages.

During recent visits to manufacturers of packaging machinery, I've been assured that automatic equipment, heretofore available only for paper or cellophane, is now available for polyethylene and other thermoplastic films. The machine suppliers now have automatic equipment to package many items; to mention only a few—paper plates, napkins, toilet tissues, paper towels, spark plugs, sheets, pillow cases, writing paper and envelopes, underwear and shirts. Each of us, resin producers, film producers, and converters, must now back the effort of the machinery manufacturers and sell automatic overwrap packaging to end users.

Forming, filling and sealing machinery has been available for polyethylene for quite a number of years. However, it has been a rather dormant market for manufacturers of this equipment. The Compak (manufactured by Hayssen Mfg. Co.), the Transwrap (manufactured by Package Machinery Co.), the Stokeswrap (manufactured by the Stokes & Smith, Division of FMC), and the Robowrap (manufactured by the Lynch Corp.) have not been sold nearly to the extent that was originally projected as possible markets. Other manufacturers of pouch forming equipment report satisfactory sales but not outstanding sales as was predicted. Within recent months all of the manufacturers of this type of equipment have revamped their equipment to reduce the amount of film per package and speed up the packages per minute off the machine.

This article discusses mainly the recent advances in automatic overwrap equipment to handle polyethylene film. Overwrap has now become a reality after many years of tedious trial-and-error experiments. Manufacturers of overwrap equipment have found that polyethylene film presents new handling problems due to its limpness, static content, critical sealing temperature and high tear resistance. Machinery which works satisfactorily on cellophane or paper has had to be completely redesigned to handle polyethylene film. The machinery manufacturers and manufacturers of resin and film found that:

1. knives had to be angled slightly so that a scissors cut was made at the film cut off;
2. the film had to be carried by some means from the cut-off to the overwrap position and could not be pushed in space as paper and cellophane are;
3. during sealing the package had to be held in place, not only during the heating cycle, but also during the cooling cycle.

Needless to say, these changes to equipment resulted in completely new machinery and an inability to offer economical conversion units for existing equipment. Several manufacturers of machinery have informed me that they can convert, but the cost of conversion is within a couple thousand dollars of the cost of a new machine. Many manufacturers are now allowing trade-ins on old equipment. The frames and some of the conveying equipment of the old machinery are occasionally used in producing new equipment. Nearly all of the new equipment will handle cellophane as well as polyethylene.

Let's now look at the equipment available from some of these manufacturers of film overwrapping equipment. Some of the features of each company's machine will be noted. It should be clearly understood, however, that this information was freely passed on to my company for inclusion in this paper, and we do not guarantee nor warrant any of this information nor do we endorse any specific machinery manufacturer. For those

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of you who are interested, literature on all of this equipment is available from each of the manufacturers. An information request card to them will be well received and quickly handled.

Henry Knoechel, sales manager of Hayssen Mfg. Co., says that all of their equipment which formerly worked on cellophane or peper is now available for use with polyethylene film. As early as 1954, this company offered polyethylene overwrap machinery for sale to the textile trade (mainly, sheets and pillow cases). These machines, some still in operation, however, did not incorporate the speed desired in automatic overwrap equipment and were not too well received. Last November, however, Hayssen announced the development of a napkin overwrap machine which operated at higher and more economical speeds. Equipment is now available from this company to overwrap packages ranging in size from 2" to 25" long by 1½" to 12" wide by 0" to 4½" high. These machines are also available for overwrapping bundles as well as single packages.

The speeds of the Hayssen machines vary from 20 to 60 packages per minute depending upon the size of the package and the film stiffness. Normally, the machines will have an optimum speed range of from 35 to 50 packages per minute. This speed is easily attained and the consistency of good packages is excellent.

All of Hayssen's equipment is adaptable to electric eye operations so as to position the printed film accurately on the face of the product. Their machines can be used with top-labeler and printer attachments. Their research department informs me they have successfully overwrapped products in trays and cartons, soft goods, napkins, envelopes and paper packages, toilet tissues (2 and 4 roll packs), and even bread. Hayssen informs us, however, that the bread machine is not high-speed and, therefore, is at present of little interest to the bakeries.

Hayssen has recently purchased a company (soon to be announced) which has developed a horizontal bag wrapping machine similar to the Hudson-Sharp Campbell polywrapper. This new machine, available within a few months, will wrap items in a horizontal bag type of package at speeds of 120 per minute and up.

At present, the Hudson-Sharp Machine Co. has a wrapper known as the Campbell polywrapper. This machine simulates an overwrap package but tends to be actually a bag overwrap for a given item. Several models of this machine are available.

The model 2W8 has been designed specifically for men's hosiery and similar products. The resulting package is neat in appearance and has a lap seam on the back and crimp-sealed extended ends. The product is fed by means of chain flights to a receiving conveyor and then directly on to the tube former where the film is formed around the package. The bottom seam of the package is actually made on the top of the package as it passes through the machine. The overwrapped product passes down a conveyor where crimp seals and cut-offs are made dependent upon the length of the package. The machine operates at speeds of 60 to 120 per minute.

The Hudson-Sharp model 2W10 Campbell wrapper is also designed to use polyethylene film. This machine has been developed specifically for pie crust sticks and overwraps them at speeds of 70 to 80 units per minute. The operation of the machine is similar to the operation of the 2W8 previously mentioned. Actually, the difference in the machine is size of package handling and the sealing mechanism which uses impulse heated flat shoes instead of hot wire and crimped welds. This machine has been used to overwrap other items such as prewetted cellulose sponges and affords excellent protection due to the very positive seals produced. Electrical eye attachments to make the end seals perfectly and index them with printed film are also available for the machine.

Package Machinery Co. has quite a complete line of machinery which will handle polyethylene film and even polyethylene extrusion coated board stock. The most well known models from this company are the FA and FA-2. These are overwrap machines which will handle cartons, trays, and flat objects. The machine uses a Teflon coated glass fiber belt for conveying and sealing the packages. The bottoms of the packages are sealed by means of a reciprocating hot bar. The FA operates at speeds of 30 to 100 units per minute with package sizes from 2" x 1-7/16" x 1" to 11½" x 5-5/8" x 3½". FA-2 operates at speeds of 20 to 60 units per minute with packaging sizes from 2" x 1-7/16" x 1" to 11½" x 7⅝" x 4½". The ends of packages have double point folds. The machines are used for wrapping candy boxes, textiles, cigar boxes, cigarette cartons, stationery, whiskey boxes, soap boxes, cookies and paper goods.

Two other machines very similar in construction produced by Package Machinery Co. are their models U-7 and BW-7. These machines are all modifications of a single overwrap machine. Each will handle a different size and each operates at a different speed. The machines can be used for wrapping toilet tissues (double or four packs), textiles, and also bread. Maximum packaging size on the U-7 is 18" x 9" x 6" package. The BW-7 is the automatic bread wrapping machine with attachments for installing an innerband and also placing end labels on the package.

Another machine manufactured by this company is the DF-1. This machine is used for overwrapping small packages such as candy bars and spark plugs with under-folded polyethylene film. These machines will operate at speeds of approximately 120 per minute.

Quite recently, the Package Machinery Company has released a booklet describing all of their machines which will operate on polyethylene film and the limitations on these machines. Copies are available from this company. Also available in this booklet is information on Package Machinery's very well known Transwrap equipment and on their new carton forming equipment which will work on polycoated board stock.

Battle Creek Packaging Machines, Inc., has successfully developed a machine which will overwrap with unsupported polyethylene film. At the recent Packaging Show and Packaging Machinery Show, the Battle Creek Co. showed a machine overwrapping paper envelopes. This machine is known as their Model No. 43 cake wrapping machine and is produced either to end-fold or under-fold. The possible package sizes on this machine are 3" to 10" long, 2" to 4½" wide, and ½" to 4" high. The machine operates at speeds up to 60 per minute. Other applications adaptable for this machine other than paper envelopes and paper are soft iced cakes, cup cakes, turnovers, clothes pins and other wooden products, greeting cards and many novelties.

At present, Battle Creek is planning to convert their Model 47 machine which will operate up to speeds of 65 per minute and take slightly larger packages. The model 47 is used for textiles, paper products, bakery products such as large buns and cakes, and specialty items which are put in cartons or open top trays.

This company plans to convert and make available the Model No. 46 machine to use polyethylene film. This machine will operate at speeds near 75 per minute and take small packages and bundle them in groups of 6 to 8 and then overwrap.

This company has a new and unique patented system for sealing the packages shut. Each package is held individually as it is carried through the machine and, therefore, there are no limitations on the speed with which sealing can be accomplished. They inform me that no longer do they have to worry about sliding or nontracking belts. Their newly-designed method is patented and trade-marked Thermopad.

Wrap-King Corp., now has two types of machines which will handle polyethylene film. These machines will also handle other heat-sealable films. Their machines include the P-2 which is used for overwrapping paper plates, cut up poultry, bearings, vegetables, fruits and candy or any item which is sold in a tray. The machine pushes the product up into the film and the film in turn is tucked under the package and heat sealed. The machine operates at 45 packages per minute. It also can be used satisfactorily with a shrinkable type of polyethylene film. The machine is now available with a heating tunnel manufactured by the Great Lakes Sealing & Equipment Co. to cause shrinkage in the film. This machine incorporates a new brake and clutch assembly developed by Wrap-King which works very well with electric eye positioning of the printing. The brake and clutch are so accurate that the film can be cut on the spot even if printing varies within ± ½". This will enable the machine to index the printing on the package perfectly.

The Model B and B-2 machines have been for sale since last January 1. These machines are bundle and overwrap machines and work satisfactorily with polyethylene film. Wrap-King has actually checked film from Alathon 34 polyethylene resin of medium density (0.930) on this machine and reports that it operates at least 25% better than other lower density polyethylene films. These machines lend themselves to overwrapping packages of napkins and other soft goods and also the overwrap of stacked cardboard boxes such as those used for packaging spark plugs and similar small items. The machine operates at a speed of 50 to 60 packages per minute. It produces a double point fold along each side of the package and a lap seam on the bottom of the package. The package size limitations for the machine are as follows: length of package 4½" to 14", width of package 4½" to 9", and height of package ¼" to 5".

Oliver Machinery Co. is about to introduce a new overwrap machine to the packaging industry which will handle polyethylene film. Heretofore, this company has manufactured machinery for overwrapping bakery items using cellophane and paper. This machine at present is undergoing trial runs at the company's main office in Grand Rapids, Mich. Overwraps will be made on sheets, boxes of candy, work gloves, napkins, bakery goods, and non-sliced bread.

The Oliver machine will wrap packages in lengths from 3⅛" to 15", in widths from 2" to 9½", and in heights from 1" to 6". The maximum film roll width which can be used on the machine is 28". The minimum roll width is 6". The machine will cut off film in any length from 5" to 24". The normal speed for operation of the machine is from 20 to 40 packages per minute. However, with a decrease in the package size and a change in the packaging film, speeds can be increased to 55-60 packages per minute.

This machine, unlike the rest of the overwrap machines, conveys the film into the wrapping area by means of a belt over a vacuum chamber. This principle of conveying was adopted by Oliver in order to make an exceptionally tight package. I have observed trials on overwrapping napkins, which intentionally pulled the napkin bundle into a round pack causing it to lose its rectangular shape.

The machine, when commercially available, will be available with photo-electric eye, a top-labeling device, and a longer length of feed, if necessary. The company states that the machine can be changed from one size of package to another in a very short amount of time, approximately 7 to 10 minutes. The machine has a self-contained vacuum system and also a self-contained refrigerant system for a coolant in the sealing section.

At present this company has no plans to introduce the machine formally. They plan after completing the trials on their present model to place it in a nearby location to check its operation under continuous running. They hope to have at least 3 machines in use within the next year.

Other companies are also proceeding with development of machines for overwrap or modifications of bagging machines to improve their general operation. Many companies such as American Machine & Foundry Co., the largest manufacturer of bread wrap equipment, are working toward conversion of their present equipment to use polyethylene film. Quite recently the Amsco Packaging Machinery Co. introduced their Amscomatic 100 which is a semi-automatic type for overwrap application.

With all of these new and very interesting developments in packaging with polyethylene film, we now have the opportunity to increase our markets for polyethylene film significantly. Our success is dependent on how well we help sell overwrap equipment. The machinery manufacturers, as indicated by this information, have not been dormant, but have been working toward improvement in handling polyethylene film. Each of us should now stand behind them and help develop sales for the equipment which they now have available.

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Polyolefins Look for More Container Applications

(Continued from page 25)

curves of metal, glass and paper compared with plastics.

Eventually the blown container market may be divided into two categories of producers. First is the small manufacturer restricted to relatively small runs and specialized containers due to limited capital and sales outlets. While the total volume of plastics consumed will be attractive, lack of sustained demand, seasonal variations and relatively highly priced finished product place these producers at a competitive disadvantage. On the other hand will be the adequately financed company capable of large volume production (millions of gross) which can meet the financial, supply and performance requirements of customers in the soap, detergent, light household chemical, cosmetic and pharmaceutical fields. (It has been estimated that potential in these industries approaches 3-3.5 billion containers per year, or a potential volume of 180-200 million pounds.) The successful operator in this area will be the one experienced in production know-how, efficient in automation (molding, inspection, printing and packaging), and strongest in distribution, market development, engineering and styling.

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Improving Electrical Properties of Epoxies

The variation in electrical properties of a reaction product of bisphenol A and epichlorohydrin are determined with respect to percentage of curing agent, the chemical structure of the curing agent and the deleterious effects of water and heat.

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Furane Plastics, Inc.

EPOXY PLASTICS are influenced in a large measure by the nature of the curing agents used to cure the liquid resins. Both mechanical and electrical properties are affected, not only during the cure or polymerization period, but also as fully cured plastics. In our study and development of epoxy electrical potting and encapsulating compounds, we have found it desirable to develop materials with optimum electrical properties and then follow by filler applications to realize optimum mechanical qualities. Sometimes it is necessary to compromise one property value to achieve specific qualities in another, although usually good, basic electrical properties determine the starting point.

Test Procedures

In examining the influence of various curing agents upon the electrical properties of epoxy resins, a standard liquid epoxy resin was selected for test purposes. General characteristics of the liquid epoxy selected (reaction product of bisphenol A-epichlorohydrin) showed the following characteristics; in the charts it is identified as Epoxy Resin I:

Viscosity @ 75°F	16,000 cps
Epoxy Equivalent	195 grs./Mol. equiv.

Room temperature curing agents primarily were selected for test purposes. These included:

A. Ethylene Diamine	$NH_2 \cdot CH_2 \cdot CH_2 \cdot NH_2$	EDA
B. Trimethylene Diamine	$NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot NH_2$	
C. Tetramethylene Diamine	$NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot NH_2$	
D. Diethylene Triamine	$NH_2 \cdot CH_2 \cdot CH_2 \cdot NH \cdot CH_2 \cdot CH_2 \cdot NH_2$	DETA
E. Triethylene Tetramine	$NH_2 \cdot CH_2 \cdot CH_2 \cdot NH \cdot CH_2 \cdot CH_2 \cdot NH \cdot CH_2 \cdot CH_2 \cdot NH_2$	TETA
F. Tetraethylene Pentamine	$NH_2 \cdot (CH_2 \cdot CH_2 \cdot NH)_3 \cdot CH_2 \cdot CH_2 \cdot NH$	TEPA
G. Hardener 9810	Proprietary Modified Aliphatic Amine	

The curing agents were reacted in the correct stoichiometric proportions with the epoxy resin, one active hydrogen per epoxy group, and cured 24 hours at room temperature followed by a post cure of two hours at 200°F. The following tests were adopted:

Dielectric Constant and Dissipation Factor	—ASTM D150-54T
Arc-Resistance	—ASTM D495-56T
Volume Resistivity	—ASTM D257-57T

In some instances tests were repeated after aging periods of one week at 300°F, in an air-circulation oven and in other instances after one week immersion in water at room temperature. Dielectric constant and dissipation factors were determined from 60 cycles to 10 mc/sec. When these electrical parameters were evaluated at different temperatures, 1-kc frequency served as the excitation.

Effect of Per Cent Curing Agent

It has been brought out in other publications that optimum electrical properties for amine-cured systems occur at the correct stoichiometric ratio of hardener and epoxy resin. It may be of interest to examine Fig. 1 which depicts dissipation factor at room temperature (75° to 80°F) for various frequencies for 5, 10, and 15% diethylene triamine and Fig. 2 for HN-9810 (14 to 20%) at various frequencies. Standard Epoxy Resin I was used throughout. An anomalous effect appears for 5% DTA. Because dielectric constant and dissipation factors at 1 kc at different temperatures proved to be

This paper was presented at the Regional Technical Conference of the Golden Gate Section of SPE.

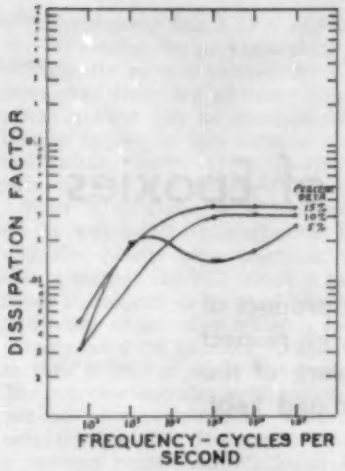

Figure 1. The effect of per cent diethylene triamine on epoxy resin at different frequencies.

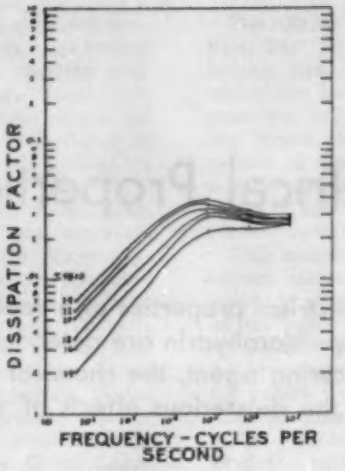

Figure 2. Dissipation factor at various frequencies for epoxy resin HN-910.

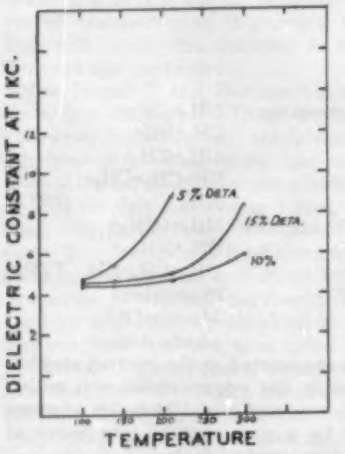

Figure 3A. The effect of temperature on dielectric constant for DETA cured epoxy.

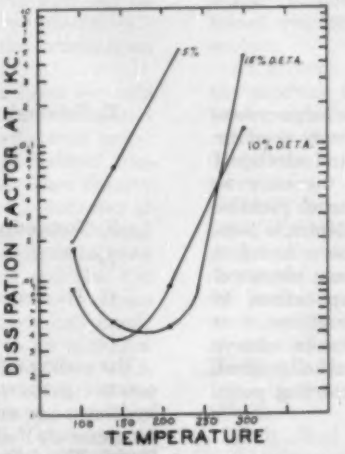

Figure 3B. The effect of temperature on dissipation factor for DETA cured epoxy.

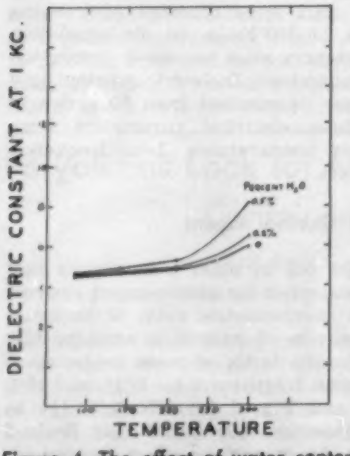

Figure 4. The effect of water content on dielectric constant of EDA cured epoxies at different temperatures.

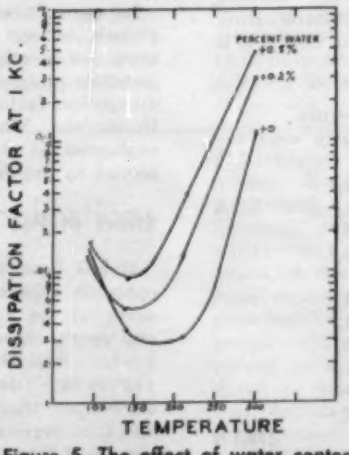

Figure 5. The effect of water content on dissipation factor of EDA cured epoxies at different temperatures.

useful criteria for examining the efficacy of a system, Figs. 3A and 3B were prepared. Lower values of dielectric constant and dissipation factor were considered as criteria of better stability for a given resin system. The abrupt rise of dielectric constant with increasing temperatures, which occurred for 5% diethylene triamine, is indicative of insufficient chemical cross-linking and thermal instability. Figs. 3A and 3B showed lowest dielectric constant and dissipation factor at 300°F, for 10% DETA, which was close to the stoichiometric ratio.

Another factor of consequence, particularly in the aliphatic polyamines which absorb water quite readily from the atmosphere, is the effect upon the electrical properties of the cured epoxy resin. Dielectric constant (Fig. 4) and dissipation factor (Fig. 5) showed a marked dependence upon water content. Ethylene diamine (stored over anhydrous calcium chloride) was reacted with liquid Epoxy Resin I, and portions thereof combined with 0.2% water (based on total weight), and 0.5% water (based on total weight). Results indicate higher values of dissipation factor and dielectric constant at elevated temperatures and a more abrupt rise with higher water content. On the other hand, differences in dielectric properties over a range of frequencies were relatively minor for the system in question with different water contents. These data are not plotted inasmuch as the results shown for ethylene diamine later in this paper at various frequencies is indicative of the data with added water.

Influence of Structure of Curing Agent

The low cost and ready availability of curing agents such as diethylene triamine and triethylene tetramine have tended to divert interest away from other room temperature curing agents. Several commercially available curing agents of different chemical structure were selected and used "as is" in curing liquid Epoxy I. The dissipation factors at different frequencies are shown in Figs. 6 and 7. Dielectric constants did not vary greatly for these measurements as shown in Table I. In trying to reach some conclusions from Figs. 6 and 7, one may recognize that the influence of aging for one week at 300°F, appears to raise values of dissipation factor at lower frequencies, suggesting some degradation has taken place, contributing to

greater losses. With respect to the chemical structures of the curing agent, there appear to be advantages to a greater spacing between the amino groups and to the higher molecular chain length of TEPA over TETA over DETA over EDA. These advantages, denoted by lower dissipation factors at lower frequencies, are relatively small in magnitude.

At 1-kc frequency, the changes in dielectric constant and dissipation factor with increasing temperature are most revealing. Fig. 8, for example, shows minimum dissipation factors between 150° to 200°F, for most of the curing agents used. One exception is the heat-cured meta-phenylene diamine system included for comparison purposes. The rise in dissipation factor after the minimum is attained is abrupt and no doubt indicative of thermal instability in the epoxy resin system —the more abrupt and the higher the rise, the less stable. Also indicative is the change in dielectric constant and dissipation factor at 1 kc, after one week exposure to 300°F. These changes are shown in Table II. The specific advantage of meta-phenylene diamine is to be noted, although among room-temperature curing agents the advantages of thermal stability appear to lie in trimethylene diamine and tetraethylene pentamine—not only because of lower values, but also because of minimal changes after one week at 300°F. In the light of these findings, it becomes difficult to interpret the arc resistance data in Table I.

For a more complete perspective of dielectric constant at various temperatures, Fig. 9 is offered, although dielectric constants for A and C curing agents at 350°F, were outside the range of the equipment being used for measurements. The curves for H, B, and F appear the most acceptable of curing agents evaluated for high temperature stability of electrical properties.

Volume resistivity at various temperatures is plotted in Fig. 10. Curing agents A to E follow a rather regular pattern, without much distinction from one curve to the other. Meta-phenylene diamine demonstrates the uniqueness of the heat-cured aromatic amine, which possesses better heat resistance than the room-temperature curing systems. Of interest, however, are the data in Table III, where small distinctions can be made, such as changes at 300° and 350°F, volume resistivity after one week exposure in air to 300°F. Processes of

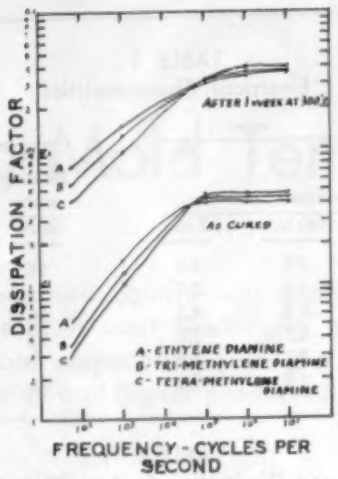

Figure 6. The dissipation factor at various frequencies for Epoxy Resin 1 for different hardeners.

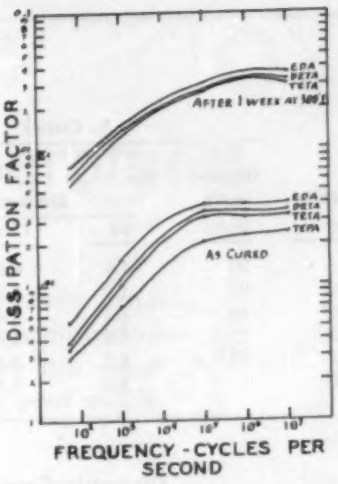

Figure 7. The dissipation factor at various frequencies for Epoxy Resin 1 for different hardeners.

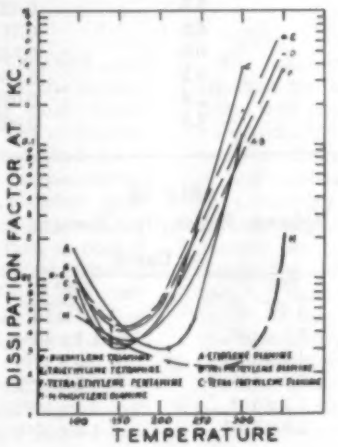

Figure 8. Dissipation factor vs. temperature for different hardeners.

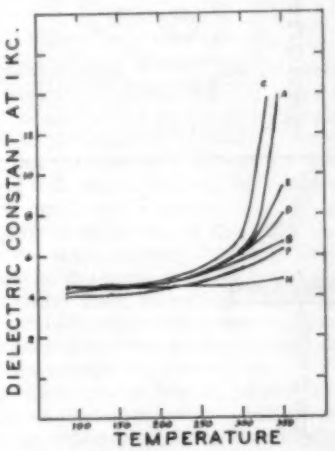

Figure 9. Dielectric constant vs. temperature for different hardeners.

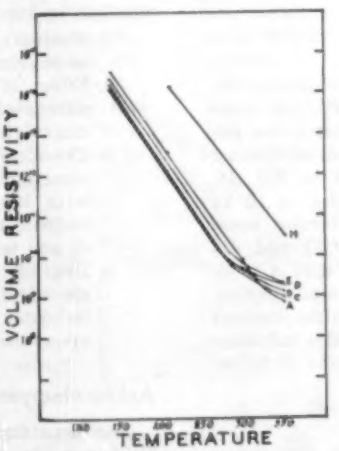

Figure 10. Volume resistivity at various temperatures for Epoxy Resin 1 plus several curing agents.

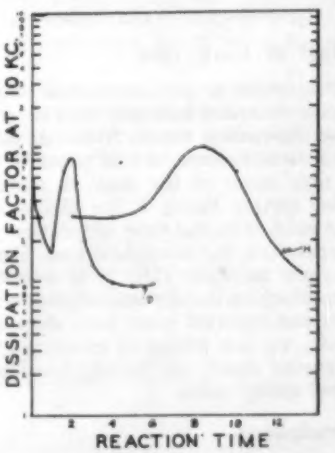

Figure 11. Variation of dissipation factor after combining hardener and epoxy resin.

TABLE I
Electrical Characteristics

Curing Agent	As Cured: Arc Resistance Secs.	As Cured: Dielectric Constant 60	1 kc	100 kc	1 mc	After one week at 300° F: Arc Resistance Secs.	Dielectric Constant 60	1 kc	100 kc	1 mc
A	80	4.6	4.5	3.8	3.6	96	4.2	4.1	3.7	3.5
B	87	4.6	4.5	4.0	3.7	74	4.3	4.2	3.7	3.5
C	90	4.5	4.4	3.9	4.1	70	4.2	4.2	3.7	3.5
D	73.6	4.3	4.2	3.8	3.6	73	4.1	4.0	3.6	3.4
E	72.3	4.3	4.1	3.7	3.6	79	4.0	4.0	3.5	3.4
F	—	3.9	3.9	3.6	3.4	—	—	—	—	—

TABLE II
Dielectric Constants and Dissipation Factor (D) at 300°F, and at 1kc

Curing Agent	As Cured: K	As Cured: D	After One Week at 300° F: K	After One Week at 300° F: D
A	6.0	0.11	7.5	0.29
B	5.8	0.103	6.4	0.15
C	6.9	0.34	12.0	0.72
D	6.0	0.145	6.1	0.17
E	6.1	0.184	6.6	0.24
F	5.4	0.088	—	—
H	4.5	0.0024	4.5	0.006

TABLE III
Volume Resistivity Ohm-cm

Curing Agent	As Cured: 300° F	As Cured: 350° F	After One Week at 300° F: 300° F	After One Week at 300° F: 350° F
A	5.6×10^{9}	8.7×10^{8}	9.4×10^{9}	6.3×10^{8}
B	3.9×10^{9}	1.4×10^{9}	1.2×10^{10}	1.3×10^{9}
C	4.7×10^{9}	9.5×10^{8}	1.8×10^{9}	1.9×10^{8}
D	6.0×10^{9}	2.5×10^{9}	1.0×10^{10}	8.7×10^{8}
E	7.1×10^{9}	2.1×10^{9}	7.8×10^{9}	8.3×10^{8}
H	1.6×10^{12}	4.3×10^{10}	5.6×10^{11}	2.8×10^{10}

degradation can usually be picked up as markedly lower volume resistivity values.

Effect of Cure Time

Cure time or polymerization time after mixing together resin and hardener does have a decided influence upon dissipation factor. Although this aspect is not the immediate concern of this paper, it may be of interest to note some of the data as represented in Fig. 11. After mixing Epoxy I, the dissipation factor at 10 kc was read until the time of gelation and after—at room temperature for metaphenylene diamine (H) and diethylene triamine (D). It is noteworthy that a peak is reached—generally coincidental with time of gelation. This was reported more fully elsewhere. In the current study, we are primarily concerned with the influence of curing agents on the electrical properties of fully-cured epoxy resins.

Conclusions

There are many variables influencing the electrical properties of epoxy resins and in this paper we have endeavored to determine the effect of the following upon a liquid reaction product of bisphenol A and epichlorohydrin:

1. Percentage of curing agent—Optimum appears at stoichiometric ratio.
2. Effect of water—The deleterious effect is apparent when dissipation factor and dielectric constant are observed at evaluated temperatures.
3. Chemical nature of curing agent—There appears some evidence that better properties are obtained with higher molecular weight aliphatic polyamines, and in tri-methylene diamine over the di and tetra.
4. Degradation under heat—Re-examination of electrical properties after one week at 300°F, indicates some evidence of degradation for the epoxy resin under study.

Acknowledgements

The assistance of Delsen Corporation of Glendale, California, in conducting electrical measurements is gratefully acknowledged.

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Controlling Mold Temperatures

Your mold temperature control unit cannot achieve ideal conditions by itself. It must work with molds constructed according to sound engineering principles. Here are some keys to better quality and higher production from your molds.

H. A. Meyrick
Industrial Manufacturing Corp.

THE DEGREE of control that can be obtained over mold temperatures is dependent both on the equipment used and the construction of the mold. Good mold construction requires adherence to the principles of heat transfer. These principles are analyzed here as they apply to the control of mold temperatures, with graphic representations to illustrate what goes on in the mold as the hot plastics enters it, gives up its heat, and warms the mold, which in turn is cooled by the heat transfer medium. Water is the heat transfer fluid considered in this article. Other fluids of lower specific heat and conductivity can be treated in similar fashion, although some differences may appear in comparison with water.

Injection molding of thermoplastic materials is a mass production process utilizing the basic factors of pressure, time and heat. All three of these factors can and should be measured.

Fundamentally, the injection molding process begins by adding heat to a solid to convert it to a fluid. The hot fluid is injected by pressure into a mold where the heat is removed to reconvert it to a solid in the desired form. This process is repeated under a uniform time cycle. Variations in any of the three basic factors will affect either one or both of the other two.

Fig. 1 is a time-temperature graph showing five cycles, the first three of which are under uniform conditions of all the process variables. It must be understood that the cycle of the press is actually a heat cycle, and that the time cycle must be set to coincide with the heat cycle. The fourth cycle shows the effect on time of an upward variation in the temperature of the plastic. If the time cycle is not lengthened, the casting may be soft. The fifth cycle shows the effect on time of a downward variation in the temperature of the plastic. This could result in a "short shot" or defective casting. The shaded areas illustrate the amount of heat which must be removed during each cycle.

The mold, of necessity, must be capable of withstanding the high pressures involved, and this mass of metal will pull the heat out of the plastic even though no provision is made in the mold to control it. Under these conditions the flow of heat will follow the path of least resistance and will not necessarily be uniform. In a multiple cavity mold, for example, one of the castings might be ready to come out of the mold in a shorter period of time than another, but the timer controlling the opening of the mold is set to accommodate the slowest. In another mold, where one area of the mold surface is at a different temperature than another, the casting might not have a uniform surface finish, and the molecular structure might vary.

There is a mold temperature which, in combination with the other process variables, will produce the optimum results both in time and uniformity of quality of the castings. In general, the lower the mold temperature the faster the heat will be removed, but it frequently may be necessary to increase the fluid temperature or pressure to insure filling the cavity. This may neutralize the "advantage" and result in a longer cycle because there is more heat which must be removed.

The heat load being intermittent, the mold temperature also fluctuates during each cycle. Fig. 3 shows five cycles, the first three of which are under uniform conditions of both time cycle and heat cycle. The

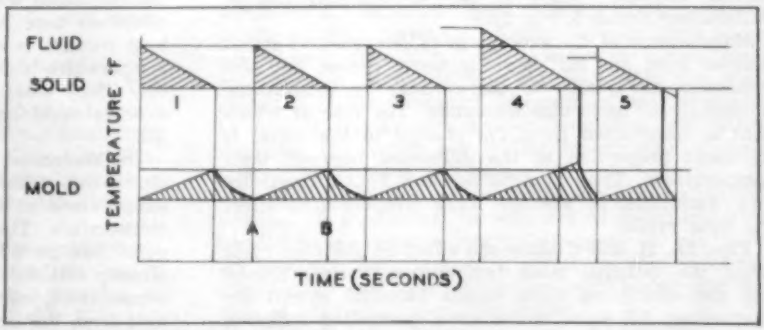

Figure 1. The relationship between time and heat.

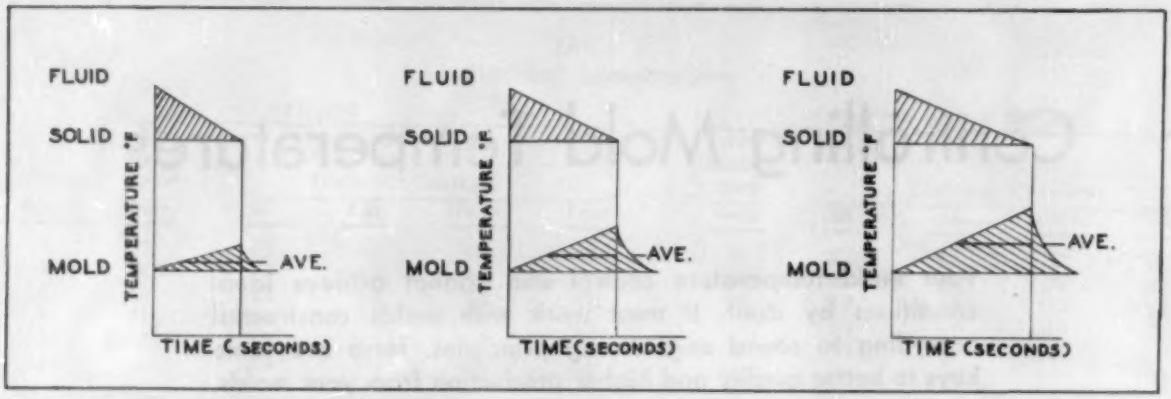

Figure 2. The effect of average mold temperatures on the time cycle.

fourth illustrates the effect of an increase in fluid temperature. Under a uniform time cycle this shows that the heat cycle has not been completed. The fifth illustration shows the effect of a decrease in fluid temperature. Under this condition the heat cycle has been completed ahead of the time cycle.

It is the average temperature of the mold which establishes the rate at which the heat is removed. To maintain the average temperature at the lowest possible level it is necessary to reduce the amount of temperature rise from the start to point B in the cycle (A to B—Fig. 3). The mold temperature at the start of each cycle must be held constant because it is this temperature which produces the surface finish of the casting. The time cycle is established from this point.

The temperature of the plastics material at the "solid" level, Figs. 1 and 3, is a constant for each material being cast. The temperature at the "fluid" level should be just high enough to insure filling the mold and to produce castings with the desired characteristics. When this temperature is higher there is additional heat which must be removed and the time cycle correspondingly lengthened, (cycle 4, Fig. 3). Likewise, when the temperature is lower there is less heat to be removed, but the quality of the castings may not be satisfactory (cycle 5, Fig. 3).

Maintenance of the average mold temperature at the desired level not only permits faster cycles, but also influences the quality of the castings by establishing uniformity of molecular formation. The rate at which heat is transferred from the plastics to the metal is in direct proportion to the difference between their temperatures. Time is a factor, and Fig. 2 illustrates how variations in average mold temperatures affect the time cycle.

Figs. 2A, B, and C show the effect on the time cycle when the average mold temperature varies. Shown are the effects on three molds identical except for channeling. All three molds have channeling sufficient to enable the mold temperature to recover to the same starting temperature. Fig. 2A illustrates the effect on the time cycle when the average mold temperature is only slightly higher than the starting level. This mold is adequately channeled so that the heat transfer to the circulated water is excellent. Fig. 2B illustrates the effect on time when the channeling is such that the heat transfer is only fair, resulting in an average mold temperature higher than in Fig. 2A. Fig. 2C illustrates the effect when the heat transfer is poor, and the average mold temperature is even higher than in Fig. 2B.

The molecular formation of the plastics which produces the surface finish is established by the mold temperature at the time of initial contact or starting temperature. The rise in mold temperature from this point has no effect on the surface finish since it is already established. The rise, measured by the average temperature, affects the time required to remove the heat from the inside of the casting and thereby establishes the overall time cycle. An operation in which

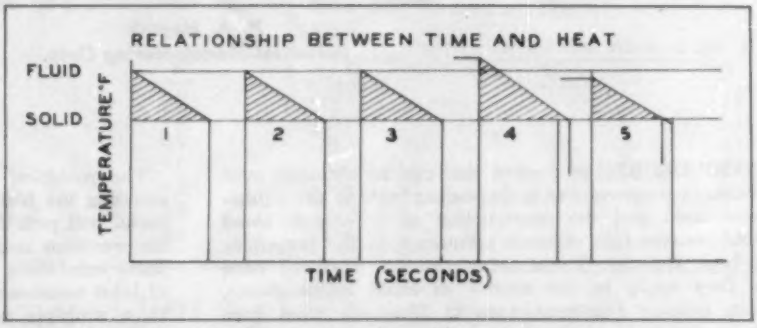

Figure 3. The effect of the heat cycle on the mold temperature.

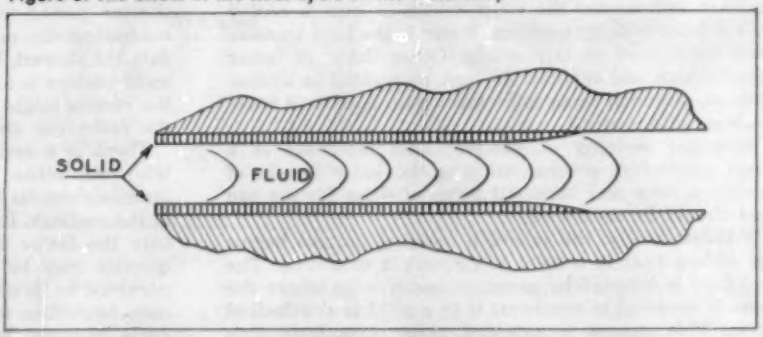

Figure 4. Magnified cross section of plastic flow in a mold.

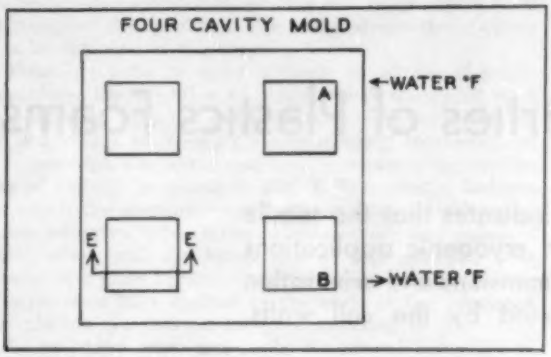

Figure 5. Four cavity mold.

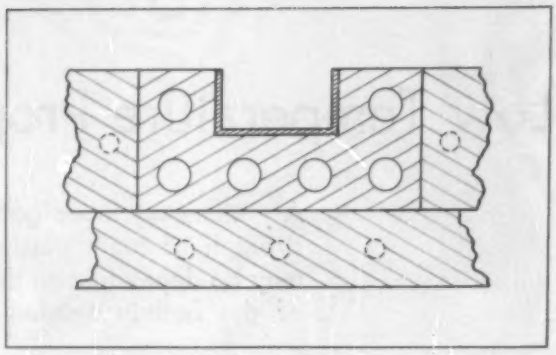

Figure 6. Section of mold.

quality of surface finish is used as an index of efficiency may be erroneous.

The flow of plastics in filling the mold and in formation of the surface finish might be illustrated in the magnified cross section of a mold, Fig. 4. There is a thin "skin" of solid plastics formed on contact with the mold surface and the fluid plastics flows inside this skin until the fill is complete. The molecular formation of this skin is established by the rate of heat removal which is a function of the thermal differential between the plastics temperature and the mold temperature. Too low a mold temperature may result in surface defects such as weld lines, crazing and scaling. Too high a mold temperature may result in sinks and blisters. The optimum molecular formation is established by the right combination of all the process controls, and small deviations from the right combination may result in defective castings or slower cycles, or both.

The internal molecular formation, inside the skin, is established by the rate of heat removal which in turn is established by the thermal differential between the plastics temperature and the average mold temperature. This involves time. It follows that the higher the average mold temperature the longer it takes to remove sufficient heat from the fluid plastics to convert it to a solid.

Removal of heat in the thermoplastic molding process must be considered as two separate and independent problems. The first is the problem of obtaining uniformity of temperature over the entire molding surface at the start of each cycle. The second is the problem of handling the heat load to result in the lowest possible average mold temperature. It is conceivable to have one without the other. Accomplishment of both of these objectives will result in a molding process producing uniform high quality castings at the optimum rate of production. Attainment of these objectives may be accomplished by use of a mold temperature control device connected to molds having properly engineered channeling.

Satisfactory control of mold temperatures utilizes the principle of high velocity circulation of water. The temperature of the water nearly always has to be controlled by either adding heat or removing heat from the water as required by the process. This controlled temperature water is circulated through the channeling built into the mold. If the channeling is adequate the results will justify the investment.

Achievement of results depends on the employment of five basic factors. The first two are a function of the control unit, and the last three are a function of the mold. These factors are shown in Table I.

Fig. 5, shows the face of a four cavity mold with the sprue and runner system omitted. The temperature of the mold surface at "A", Fig. 5, will be established by the temperature of the water in the channel underneath that point. When the temperature of the water is held constant, the temperature of the mold at "A" will tend to remain constant. To have the same temperature at "B", the water in the channeling under "B" must be the same as under "A". Since there must be a temperature change to accomplish heat transfer, this change can be held to a practical minimum by high velocity circulation. These results are a function of factors 1, 2, and 5, Table I.

Section E-E, Fig. 6, enlarged, illustrates the application of other factors. The channeling in Fig. 6 shown by dotted lines violates 3, Table I, in that the water is not in contact with the metal in which the temperature is to be controlled. The juncture between the cavity metal and the back plate offers resistance to thermal flow, resulting in a rise in the surface temperature during a cycle, Fig. 2C. The channeling shown by the solid lines indicates the desirable type of construction, and meets the requirements of 3 and 4, Table I. In addition, the channeling should be large enough to insure minimum hydraulic resistance, 5, Table I, and permit high velocity circulation, 2, Table I.

Mold temperature regulator control of mold temperatures is a technical approach to one of the variables in the molding process. Compromises may have to be made, since it will not be possible to obtain ideal conditions in all molds. The key rests with the mold designer. If his viewpoint is based on the principles in Table I, and he lays out the channeling first rather than last, the results will justify the adoption of mold temperature control equipment.

Mold temperature control units are process control devices. They must not be regarded as gadgets to help handle some nuisance heat. Cold spots or hot spots are evidence that the mold is setting its own temperature pattern and is not under control. Quality and the rate of production per hour suffer.

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TABLE I

Basic factors to achieve control

1. Water temperature must be accurately controlled.
2. High velocity circulation is required.
3. Water must contact the metal in which the temperature is to be controlled.
4. Contact area must be as large as possible.
5. Hydraulic resistance must be as low as possible.

Low Temperature Properties of Plastics Foams

A preliminary investigation indicates that the tensile strength of foam plastics in cryogenic applications may be dependent on the dimensions and orientation of the built-in notches formed by the cell walls.

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EXPANDED PLASTICS have found considerable use as cryogenic insulation in applications where only moderate thermal efficiency is required, especially where it is convenient for the insulation to be self-supporting or to provide support to other structures. The thermal gradient in which they see service, however, induces thermal stresses which can be great enough to cause failure of the insulation structure if the design does not allow for the effects of the characteristically high thermal contraction and relatively low tensile strength of these materials.

An especially severe case of thermal stresses in expanded plastics insulation occurs when the insulation is bonded to a more rigid member of the structure. A theoretical analysis of thermal stresses has been made for cylindrical geometry in which the boundary conditions approximate the case of insulation bonded to the inner surface of the warm, outer shell of a low temperature storage vessel (Ref. 1). From this analysis a prediction of the low temperature performance of such insulations can be made if they are isotropic and if their mechanical properties are known. The properties that must be known as functions of temperature are the modulus of elasticity in tension and Poisson's ratio. In addition to these properties, the tensile strength and the modulus of rigidity have been obtained at selected temperatures down to 20°K for two densities of expanded polystyrene and an expanded epoxy resin.

Both the polystyrene and the epoxy resin were obtained from commercial suppliers in the pre-foamed condition. The foam material resulting from the manufacturing process has closed cells in the case of the polystyrene, but the epoxy foam is porous. These structures result in somewhat different thermal performance for the two types of material as found previously by Schrodt et al (Ref. 2).

The average densities of the two polystyrene foams chosen for mechanical measurements were 3.0 and 4.1 lbs./cu. ft., and the average density of the epoxy foam was 5.5 lbs./cu. ft.

Experimental Methods

Normally, in order to measure the elastic properties of a solid, one would design the best specimen for obtaining each of the properties desired; but when the material is neither homogeneous nor isotropic, there are advantages in using the same specimen to measure as many of the different properties as possible. This may involve a compromise with the best dimensions for obtaining the most accurate measurements of each property, but it is worth this sacrifice in the case of plastics foams in order to minimize the effects of variations in isotropy and homogeneity. Consequently, the specimen chosen to measure the desired properties was a right circular cylinder 1⅛" in diameter and about 2½" long. The ends of the cylinder were glued to plastics holders as shown in Fig. 1. The diameter chosen was thought to be sufficiently large to include enough cells of the material so that the contribution of individual cells was masked in favor of the gross properties of the material. The approximation is better, of course, for the smaller cell size of the dense polystyrene foam.

Of the desired properties, tensile strength and Young's modulus are relatively easy to measure with tensile testing equipment which has been cryostated for low temperature service. A load cell was used to measure force on the specimen, and a dial gage indicated the

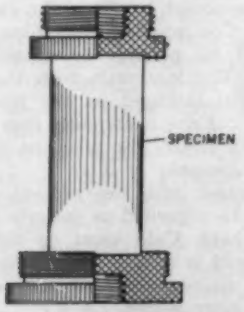

Figure 1. Foam Specimen

TABLE I
Elastic Properties of Expanded Polystyrene from 9 Specimens of Approximately 3.0 lb./cu.ft. Density

Property psi/lb./cu. ft.	Temperature °K	Direction X	Y	Z	Z/X
E/ρ	300	1510	≅1772	1955	1.30
E/ρ	195	1689	—	2228	1.32
E/ρ	76	1944	—	2657	1.36
G/ρ	300	610	≅ 600	667	1.09
G/ρ	195	650	—	698	1.07
G/ρ	76	781	≅ 757	850	1.09
G/ρ	20	956	—	1031	1.08

corresponding elongation, while a low temperature fluid surrounded the specimen. The entire stress-strain curve can be obtained in this way.

Poisson's ratio is more difficult to obtain directly; therefore, the modulus of rigidity was measured, and approximate values of Poisson's ratio were derived from it and values of Young's modulus using mathematical relationships. The apparatus used to measure the modulus of rigidity is shown in Fig. 2. The plastics holders to which the specimen was fastened with a rigid epoxy resin adhesive were screwed into concentric stainless steel tubes, and the lower end of this assembly was placed in a glass Dewar vessel for temperature stability. Torque was then applied to the ends of the specimen by placing weights on hangers attached to the inner tube by radial arms and cords. Rotational deflection of the specimen was read by noting the angular displacement of a mirror attached to the inner stainless tube. An optical lever system provided the means for amplifying and observing this displacement.

For a right circular cylinder of an isotropic material the modulus or rigidity is given approximately from this method of measurement by the expression (Ref. 3)

$$G = \frac{TL}{J\theta}$$

where T is the torque applied to the cylinder, L is its length, J is the polar moment of inertia of the circular cross-section, and θ is the relative angular displacement of the ends of the specimen. If the material is not isotropic, however, the resulting quantity is not truly the modulus of rigidity, except when the axis of the cylinder lies in certain directions depending upon the anisotropic symmetry of the material. The plastics foams measured here, it turned out, were not isotropic, but it will be convenient to call the property measured by this method the "modulus of rigidity" for the moment, bearing in mind that it is an approximation.

Discussion of Results

Both Young's modulus and the modulus of rigidity show a marked increase with decreasing temperature for the expanded epoxy resin and for the expanded polystyrene in each density. This behavior is typical of solid plastics materials (Ref. 4) and it is not too surprising to find it duplicated in the foams when we consider that the plastics cell walls of the expanded materials govern their elastic properties.

Table I shows values of Young's modulus, E, and the modulus of rigidity, G, for expanded polystyrene of 3.0 lb./cu. ft. average density. Since the mechanical properties of foamed plastics are functions of their densities, however, and since test specimens cut from the same large sample will show variations in density, comparison of the properties of different specimens can only be made after accounting for this variation. Manufacturers' literature gives mechanical properties of different types of plastics foams variously as an exponential function or as a linear function of the density. (Refs. 5, 6, 7) For the rather restricted density ranges considered in this study, a sufficiently good first approximation can be obtained by assuming the linear function. The data given in Table I, therefore, are given as E or G in psi divided by the actual density of the specimen in lbs./cu. ft.

The effect of temperature on the elastic moduli can be seen from the table for specimens cut from large samples so that their axes of symmetry lay in three mutually perpendicular directions. The properties are different in the three directions, showing that the material is not isotropic, but the effect of temperature on

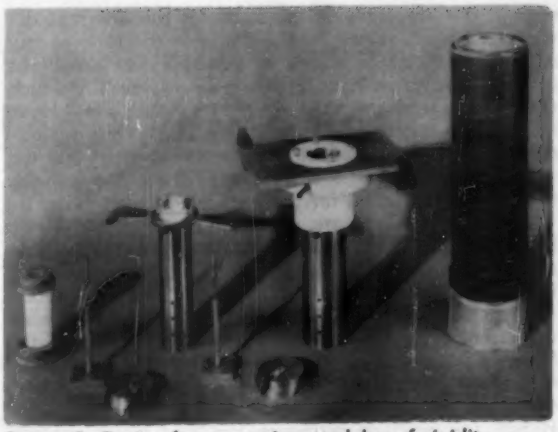

Figure 2. Device for measuring modulus of rigidity.

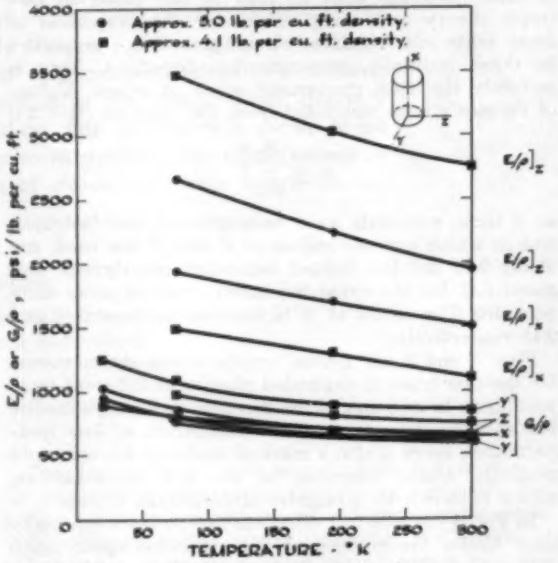

Figure 3. E/ρ and G/ρ for expanded polystyrene.

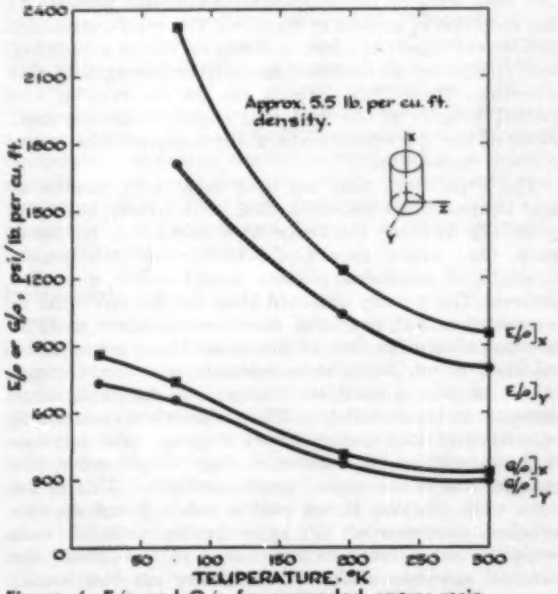

Figure 4. E/ρ and G/ρ for expanded epoxy resin.

each of the properties is the same for the different directions. This is shown by the fact that the ratio of any of the properties measured in two different directions is very nearly constant at all temperatures at which measurements were made. Fig. 3 shows the elastic moduli as a function of temperature graphically for expanded polystyrene, where it becomes apparent that the curves are all members of the same family. Fig. 4 shows the same information for the expanded epoxy resin.

Microscopic examination of thin slices of the plastic foams in different directions discloses a preferred orientation of the cells, from which one would expect their directional properties to be different. It seems reasonable to suppose that an axis of symmetry exists which coincides with the direction of expansion of the foam during manufacture. But this direction apparently changes as the growth process proceeds, to judge from samples taken from different locations in a large piece. Hence, for practical purposes, the best stress analysis of these materials after all may be one based on isotropic theory and using values for the properties of these materials which are averages of the properties in three mutually perpendicular directions. This is certainly the most convenient mode of attack. Values of Poisson's ratio computed from the relation (Ref. 3):

$$\mu = \frac{E}{2G} - 1$$

as if these materials were homogeneous and isotropic, and in which average values of E and G are used, are about 0.36 for the lighter expanded polystyrene and about 0.41 for the expanded epoxy resin at room temperature. The values at 76°K increase to about 0.41 and 0.45 respectively.

Figs. 5 and 6 are typical tensile stress-strain curves for the two types of expanded plastics at different temperatures. In addition to the increase in Young's modulus and the decrease in total elongation at low temperatures, there is also a marked tendency toward more perfectly elastic behavior at the low temperatures, which is shown by straighter stress-strain curves.

In Fig. 6 the effect of direction can be seen especially well. Under the microscope the expanded epoxy resin shows a preference for ellipsoidally shaped cells, with the long axis of the ellipsoid presumably parallel to the direction of growth of the foam. For such a structure one would expect to observe a higher Young's modulus, less elongation at fracture, and higher strength in this direction. These three effects can be observed as expected in spite of the fact that slightly different densities of the specimens make a direct quantitative comparison impossible.

The little work that has been done with plastics at low temperatures indicates that their tensile strengths generally increase markedly with decreasing temperature. One might expect, therefore, that the tensile strength of expanded plastics would follow a similar pattern. The results obtained thus far for strengths of expanded polystyrene and epoxy resin down to 76°K are not conclusive, but at this stage there seems to be no such trend. More measurements are needed upon which to base a complete theory, but the explanation appears to be as follows: While the cohesive strength of a solid plastics material may increase with decreasing temperature, the material may also become less ductile, and hence more "notch sensitive." This is the case with plastics. If we pull a notched and an unnotched specimen of the same brittle material, each with the same cross-sectional area at the break, the notched specimen will exhibit a lower nominal breaking stress than the smooth specimen because the notch

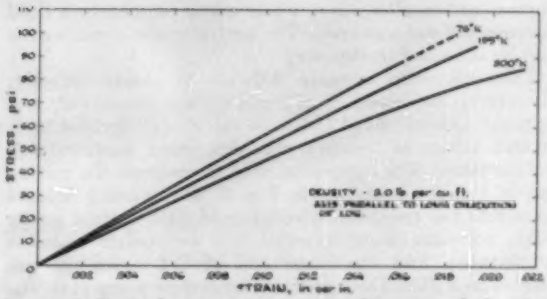

Figure 5. Typical stress-strain curves for expanded polystyrene.

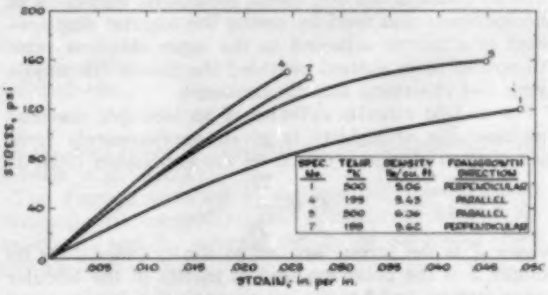

Figure 6. Typical stress-strain curves for expanded epoxy resin.

acts as a "stress raiser." Foamed plastics, of course, have built-in "notches" in great quantity where their cell walls join one another. It is conceivable, therefore, that the tensile strength of foamed plastics may be lower at low temperatures than at room temperatures because of the irregularities of its structure, even though the parent solid material has greater cohesive strength at low temperatures.

If the above explanation is correct, then the tensile strength of these materials at temperatures below which the parent solid becomes brittle may be dependent upon the dimensions and orientation of a series of critically located notches in the form of cell wall junctions. One should then expect the wide scatter in tensile data which has been obtained.

Acknowledgement

The author would like to express his thanks to Richard Greeson, who made most of the measurements.

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Studying the Electrical Properties of Casting Resins

The continuous current monitoring instrumentation together with several sample cells is described. This instrumentation graphically records the changes in conductivity of a resin throughout the polymerization process. By the use of different sample cells and temperature conditions, the resistivity may be determined under adiabatic or isothermal conditions. The resistivity of the unpolymerized and polymerized resin may be determined in the range 10^6-10^{16} ohm-cm. The uses of this instrumentation in estimating the extent of polymerization and determining the temperature dependence of resistivity are described. In addition, this instrument is shown to be useful in establishing optimum curing cycles in studying the effectiveness of hardeners, and in estimating the effects of moisture at high temperatures.

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THE PROBLEM of rapidly and accurately determining the significant electrical properties of various resins before, during and after polymerization was encountered in the study of casting resins. This study was directed toward obtaining a basic understanding of the electrical, thermal, and mechanical properties, and the polymerization characteristics of these materials. Since these resins were to be used for the encapsulation of electronic components in ordnance applications, a knowledge of their electrical properties was important.

The lack of a simple method which would quickly give accurate results prevented a full evaluation of the electrical properties of these compounds. The standard methods for determining the electrical resistivity of these materials were time consuming and limited in application. Often machining of the sample was required, and in many cases the accuracy of the determination was questionable.

The development of the continuous current monitoring device (Ref. 1) has to a great extent solved these problems and the electrical properties and polymerization characteristics may be rapidly determined in a few hours on a single casting. In addition to the electrical resistivity, which can be measured under various conditions of temperature, humidity, and extent of polymerization, both the dielectric constant and loss tangent can be determined on the final casting as a function of the frequency. Standard techniques are used in these two measurements.

Based on a paper presented at the Second Annual Technical Forum of the Baltimore-Washington Section, SPE.

The device can be used as a research instrument, as for example, in determining the rates of polymerization under isothermal conditions at different temperatures with different curing agents. Likewise, the effects of fillers and varying amounts of curing agents can also be studied, and the effects of these variables on the properties of the cured resin evaluated. Different curing cycles can easily be studied and the effects of rapid high temperature curing, as opposed to slow low temperature curing, can be rapidly determined. This is particularly important when it is necessary to develop a new curing cycle, such as in the case of encapsulating temperature sensitive electronic components, in which complete cure must be attained at temperatures not exceeding 60°C. The techniques presented here are proposed as a general tool for use in both research and quality control work.

Instrumentation

The instrumentation used to obtain the volume resistivity of a resin before, during and after polymerization is a simple application of Ohm's Law. A Keithly Model 210 electrometer with a Keithley Model 2008 decade shunt attachment is used to monitor the current over the large range (10^{-3}-10^{-12} amperes) required to follow the polymerization process. The output of the electrometer is fed to a 1ma Esterline-Angus pen and ink recorder equipped with a timing pen. A continuous record of the conductivity of the polymerizing resin is thus obtained. This recorder is also used in determinations where the conductivity rapidly changes due to changes in temperature. A thermocouple is taped to

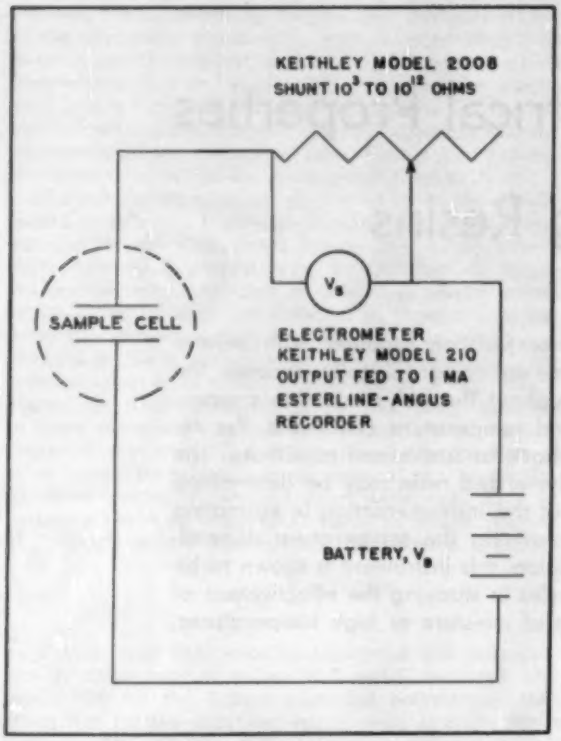

Figure 1. Wiring diagram of monitoring device.

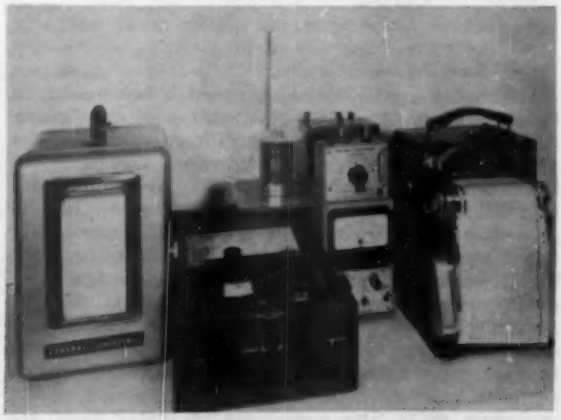

Figure 2. Current and temperature monitoring instruments.

one of the electrodes and makes it possible to measure the temperature of the resin at the electrodes. The source of the potential is a 45v battery. The conductivities were measured at a field strength of approximately 200 v/cm. A wiring diagram of the circuit is shown in Fig. 1, and a photograph of the experimental arrangement is shown in Fig. 2. Detailed instructions for the operation of the Keithley Model 210 electrometer will be found in Ref. 2.

The electrodes employed, in all but the isothermal determinations, consist of two brass strips, 0.094″ (0.24cm) thick, 1.00″ (2.54cm) wide and 2.75″ (7.0cm) long. The inter-electrode spacing, 0.080″ (0.2cm), is maintained by small polytetrafluoroethylene (Teflon) bushings. The electrodes are suspended from a polystyrene cover plate, before polymerization, by threaded brass rods soldered to each electrode. Cans have been used as expendable molds in which to cast the resin. A standard No. 1 can, 4.0″ (10cm) high and 2.6″ (6.6cm) in diameter and with a capacity of 325cc has been used. Figs. 3 and 4 show details of the construction of the electrodes, bushings and cover plate. The electrode dimensions given here have been used successfully in many applications. However, any reasonable size can be used depending on the specific application under consideration. It must be remembered that while smaller electrodes can be used, the accuracy decreases with a decrease in the area over length (A/L) ratio.

The electrodes employed in the isothermal polymerizations consist of two concentric cylinders constructed of nickel plated standard copper tubing of wall thickness, 0.0625″ (0.159cm), and threaded at one end. The interelectrode spacing is 0.13″ (0.317cm). These electrodes are attached to a Teflon base plate and a thermocouple is inserted between the electrodes to measure the resin temperature. Fig. 5 shows the details of the construction of these cylindrical electrodes.

The data plotted on the Esterline-Angus graps paper, together with the time-temperature record, are used to plot the type of curve shown in Fig. 6 which is a semi-logarithmic plot of volume resistivity vs time and a regular (Cartesian) plot of time vs temperature. Since the potential drop across the sample and the current through the sample are measured, then, by Ohm's Law the resistance may be calculated by means of Eq. 1.

$$R = \frac{V_B - V_S}{I} \qquad \text{Eq 1}$$

where V_B is the source of potential; $(V_B - V_S)$ is the voltage drop across the sample, and I is the current in amperes. The volume resistivity, ρ, is then calculated by means of Eq. 2.

$$\rho = \frac{A}{L} R \qquad \text{Eq. 2}$$

Where R is the resistance in ohms, L is the current path length in the material in centimeters, and A is the surface area of the material perpendicular to the potential gradient (area of the electrode cm²). The geometric factor, A/L, for the strip electrodes described in this paper is 86 and for the cylindrical electrodes is 48.

EXPERIMENTAL PROCEDURE

During Polymerization

Under Adiabatic Conditions

The resin and catalyst (hardener) are mixed at room temperature and stirred for five minutes, by means of a motor driven propeller stirrer, to insure complete mixing. Time is measured from the instant resin and catalyst are mixed. After complete mixing the catalyzed liquid resin is carefully poured into the can. The strip electrodes must be covered to a depth of 0.25″ (0.64cm),

to insure that the electrodes are completely encapsulated. The electrodes are connected to the monitoring device by means of short, 4-8" (10-20cm), Kel-F covered leads. The thermocouple leads are connected to a manually operated Leeds and Northrup potentiometer.

The Keithley electrometer is set at a full scale reading of 8v. Initially a current of the order of 10^{-3}-10^{-5} amps will flow, depending upon the resin being used and its temperature. However, as soon as the resin and catalyst are mixed, polymerization commences and very soon afterwards its effect is noted by an increase in temperature and a decrease in viscosity, both of which tend to decrease the volume resistivity. This effect is shown in Fig. 6, where, after an initial period of about 35 minutes, during which the temperature slowly rises, a sudden rapid increase in temperature causes the volume resistivity to fall.

At this point the rate of polymerization increases rapidly, with a resulting increase in the volume resistivity and a rapid increase in temperature. Usually gelation occurs around this point, but this instrument does not directly determine the gel point. In a very short time interval it is necessary to turn the decade shunt up several decades because of the rapid increase in resistivity. The resistivity should be continuously recorded until the resin has polymerized and cooled down, the temperature being measured at 5-15 minute intervals as a function of time.

In Fig. 6, since the reaction is occurring under near adiabatic conditions, the volume resistivity at any time is a function of both temperature and extent of polymerization. Thus, one can only compare volume resistivities measured at the same temperature. For example, the unpolymerized resin at 27°C has a volume resistivity of 3×10^8 ohm-cm, while 240 minutes later, again at 27°C, the now polymerized resin has a volume resistivity of about 10^{17} ohm-cm. This illustrates the wide change in volume resistivity between the unpolymerized and the polymerized resin.

Under Isothermal Conditions

From the previous section it can be seen that under adiabatic conditions the change in resistivity due to polymerization cannot be distinguished accurately from the change in resistivity due to temperature. The resistivity of a resin increases with polymerization and decreases with a rise in temperature. Therefore, to separate these two competing effects, it is necessary to conduct a polymerization under isothermal conditions. Under these conditions the change in resistivity will be due only to the increase in polymerization.

Typical isothermal polymerizations of an amine catalyzed epoxide resin are shown in Fig. 7. These polymerizations are conducted in the cylindrical electrodes requiring only about 13 grams of resin. The space between the two cylindrical electrodes is filled with the catalyzed liquid resin. By means of a small laboratory oven it is possible to maintain isothermal conditions within 1°C throughout the polymerization process. It will be noted that initially the time rate of change of the resistivity is large, but the rate decreases as the extent of polymerization increases. After several hours a maximum value represents a state of complete cure at the particular isothermal temperature. The time required to attain this maximum constant value of the resistivity is temperature dependent. The isothermal reactions taking place at a higher temperature will reach this value more quickly than those conducted at a lower temperature, as can be seen in Fig. 7. A detailed description of the techniques used to conduct an isothermal polymerization has been previously reported (Ref. 3).

Volume Resistivity After Polymerization

In practice, the volume resistivity after polymerization is of the most practical interest. The resistivity at 25°C is not necessarily the value obtained from the cooling curve at 25°C from a continuously monitored adiabatic polymerization. In many cases, the polymerization can be advanced considerably by post curing, which will increase the volume resistivity beyond that obtained during the initial polymerization. The test specimen is made up in the same manner as previously described, using the parallel strip electrodes. The resin is polymerized and the resistivity determined on the polymerized resin at whatever temperature(s) is desired. This is, therefore, a useful tool to study volume resistivity as a function of various curing cycles, type and amount of curing agent, and the effects of various fillers and plasticizers.

Less instrumentation is required to determine the volume resistivity on the polymerized resin than is needed to monitor a polymerization. The recorder is not needed and the potentiometer can be omitted if the specimen can be brought to an accurately known equilibrium temperature. After the polymerized sample is connected to the monitoring device, no readings should be taken for about 30 minutes to allow equilibrium conditions to be attained.

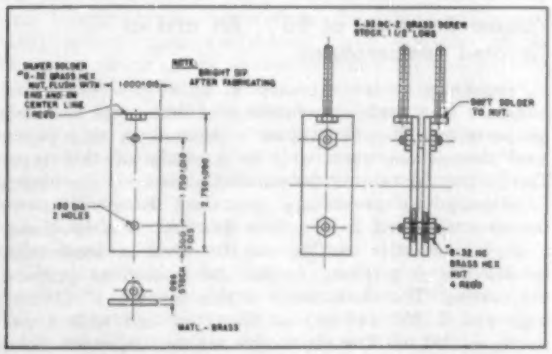

Figure 3. Strip electrode and strip electrode assembly.

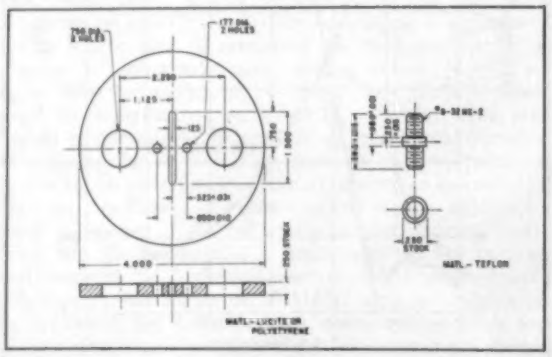

Figure 4. Top cover plate and strip electrode space.

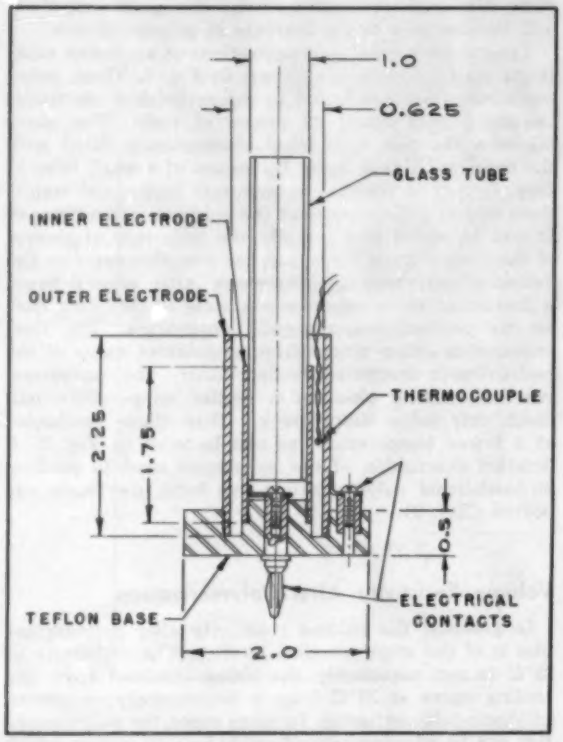

Figure 5. Sample cell for isothermal polymerization.

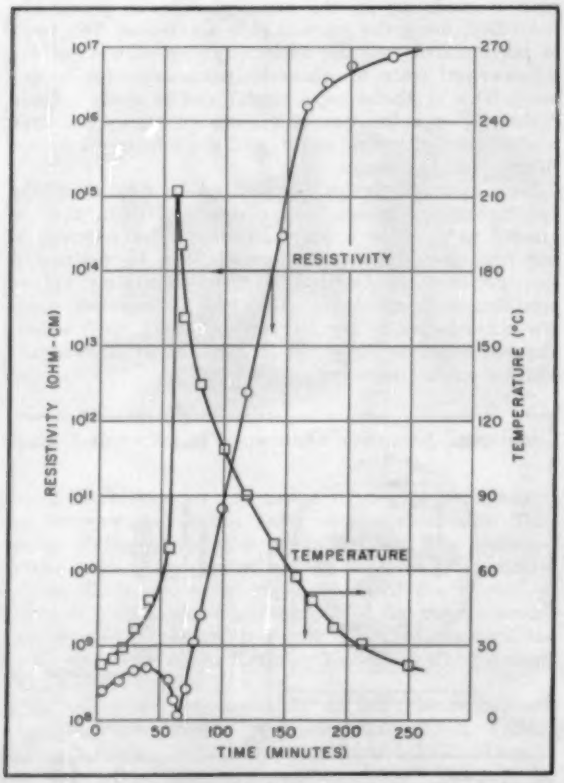

Figure 6. Typical resistivity vs time and temperature vs time plots obtained under adiabatic conditions.

Volume Resistivity as a Function of Temperature

Frequently it is necessary to use these resins at elevated temperatures, hence a knowledge of the electrical properties of these materials at elevated temperatures is necessary. The sample casting as previously prepared containing the parallel strip electrodes with an attached thermocouple can be used in this determination. Dielectrics differ from metals in that the electrical resistivity decreases as an exponential function of the temperature. The resistivity of a dielectric may be approximated by the exponential function, Eq. 3.

$$\rho = \rho_{T_o} e^{-\alpha(T-T_o)} \qquad \text{Eq. 3}$$

where

$$\alpha = \frac{d\,(Ln\ \rho_o/\rho)}{dT} \qquad \text{Eq. 4}$$

α is a constant for the fully polymerized resin and is the slope of the resistivity vs. temperature plot. T is the temperature in degrees centigrade, T_o is the initial temperature (usually 25°C) and ρ is the volume resistivity.

Before the temperature dependence of resistivity of a resin is determined, polymerization must be complete. It is important that complete cure is obtained to insure that the results are valid and reproducible. If doubt exists as to the extent of polymerization, the casting should be heated at 110°C in an oven for 24 hours before any determination is made to insure complete polymerization. If the sample has previously been completely polymerized, it will only be necessary to heat it for 4-6 hours at 110°C and to connect it to the monitoring device and potentiometer. The conductivity is then measured as a function of temperature as the sample cools from 110°C to 25°C. Usually about 2-3 hours will be required, and the recorder is used. In practice it has been found that the temperature can be read as a function of time and noted on the recorder paper. Thus a continuous record is made of the conductivity, temperature and time. The volume resistivity is calculated as previously described and plotted on semi-logarithmic paper as a function of temperature as shown in Fig. 8.

Volume Resistivity at 95% RH and at Elevated Temperatures

Frequently it is necessary to study the effects of moisture on a resin as a function of time at an elevated temperature. The techniques presented in this paper lend themselves very well to a study of this type. The casting containing the parallel plate strip electrodes is prepared as previously described. However, since the time required to complete this test is rather long, a slightly smaller casting can be used to advantage. In practice a smaller can has been used to prepare the casting. The dimensions of this can are 4" (10cm) high and 2.125" (4.7cm) in diameter, and with a capacity of 200 cc. The electrodes are so suspended from the top of the can that a space, 0.25", is left between the bottom of the can and the bottom of the electrodes. A thermocouple is taped to one of the electrodes. The

catalyzed liquid resin is then poured into the can and the electrodes are carefully covered to a depth of 0.25" by the resin. For accurate comparison of castings it is important that the dimensions of the castings are kept constant. The resin is then cured at a slow rate to minimize the possibility of any cracking occurring during or after the curing process. Cracks will allow moisture to penetrate directly to the electrodes and make any results meaningless. Should any cracks be observed the casting should be discarded. After polymerization is complete, the can is removed from the casting before any of the resistivity measurements are made.

The base value of the resistivity is then determined at the temperature desired, either by measuring the sample maintained at the elevated temperature, or by inspection of a previously prepared plot of resistivity vs. temperature for the sample under study. The casting is then placed in an atmosphere of 95% RH maintained at a constant temperature. Measurements of the resistivity of the casting are made at 24-48 hour intervals and plotted as shown in Fig. 9.

The actual manner in which the casting is maintained at the elevated temperature and 95% humidity is optional. In this laboratory a large desiccator, from which the desiccant has been removed, was used. The lower half of the desiccator was filled with water up to the base plate, and the casting set upon this plate. The desiccator was then closed and placed in an oven maintained constantly at 71°C (160°F). The actual measurements were made by removing the casting from the desiccator (but not from the oven), wiping the space between the two protruding brass screws (to eliminate surface resistivity effects) and finally measuring the resistivity of the casting at 71°C in the usual manner. Long leads (18" to 24") of Kel-F covered wire attached to the brass screw stock, protruding from the casting, makes it possible to make the measurements without having to remove the casting from the oven. As soon as the resistivity is determined the casting is returned to the desiccator.

Discussion

A number of methods have been developed for the determination of the volume resistivity of resins under various conditions. These methods all utilize the same basic instrumentation. The experimental techniques used to obtain the volume resistivity of a resin during adiabatic polymerization, are applicable for resins that have high heats of polymerization and which polymerize spontaneously at room temperature. This is the case frequently encountered in the laboratory, especially when using the amine cured epoxide resins. However, resins can be studied in which the polymerization reaction will not occur unless energy (heat) is put into the system to initiate the reaction. The resistivity vs. time plot, shown in Fig. 6, is typical of an amine catalyzed epoxide polymerization, occurring spontaneously under near adiabatic conditions. However, many other systems will have much longer initiation periods and slower rates of polymerization; hence other types of plots will be obtained (Ref. 4).

Of more practical importance are the polymerizations conducted under isothermal conditions. For example, in investigating new resin-catalyst systems, it is possible to establish rapidly the optimum curing cycle from a series of these polymerizations conducted at different temperatures. In addition the effects of plasticizers (Ref. 5), fillers, and curing agents can be determined.

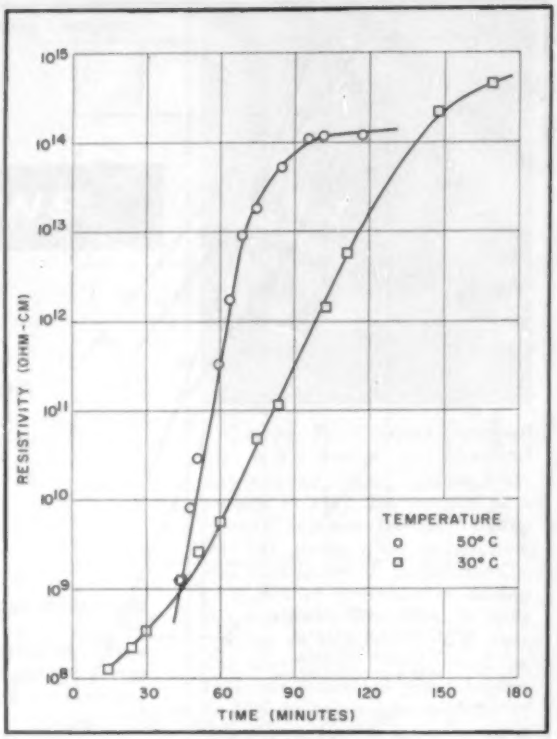

Figure 7. Isothermal polymerization of an amine cured epoxide resin.

In practice, much curing is done under approximately isothermal conditions, hence when the optimum curing cycle has been established from these isothermal polymerizations, it is only necessary to approximate the correct curing cycle in practice.

The measurement of the volume resistivity after polymerization is very useful. Aside from its usefulness as a research tool in studying the variables previously cited, this method is well adapted to quality control work and in determining the optimum electrical properties. For example, if after curing, the resistivity of a sample at 25°C is found to be 5 x 10^{14} ohm-cm, and it is known from previous work that a fully cured sample will have a resistivity of 1 x 10^{16} ohm-cm at this temperature, it can be concluded that the cure is not as yet complete and that postcuring is necessary.

Fig. 8 is a plot of resistivity vs. temperature for a number of commonly used casting resins. It will be noted that in each case a linear relationship exists over the temperature range 25°C to 110°C. This plot makes it possible to determine by inspection the volume resistivity of a casting resin at any temperature in the range covered. In addition, the exponential temperature coefficient of resistivity, α, can be calculated from the slopes of the resistivity vs. temperature plots. With this coefficient and a knowledge of the volume resistivity at 25°C, the volume resistivity at any temperature in the range of 25-110°C may be calculated by means of Eq. 4. Table 1 gives the values for α for those resins whose temperature dependencies are shown in Fig. 8.

If the resin is not completely cured and its temperature dependency determined, then upon redetermining

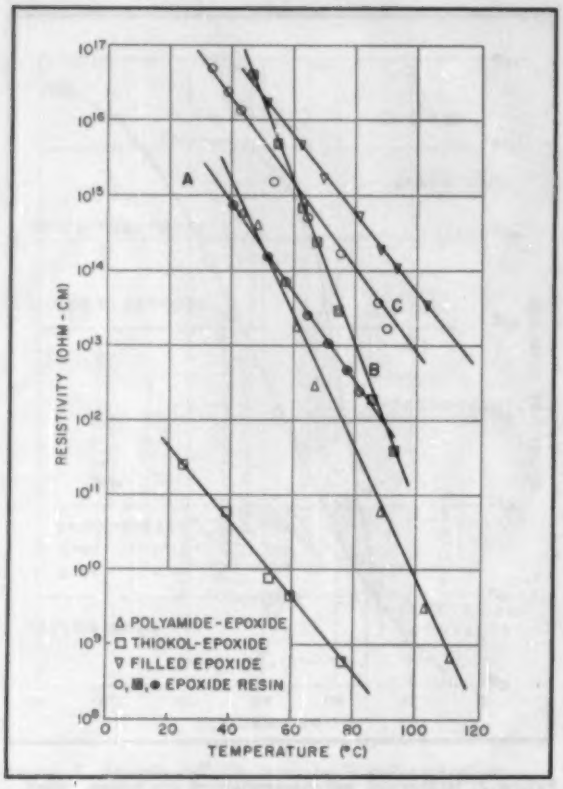

Figure 8. Temperature dependency of casting resins.

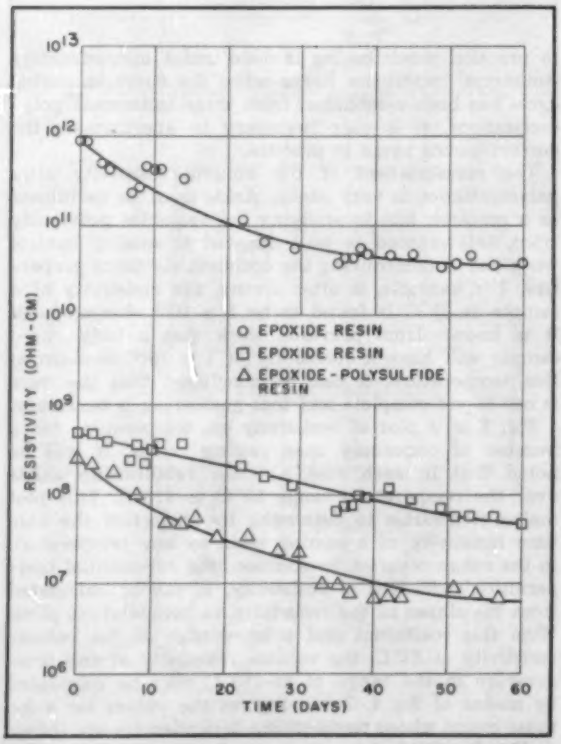

Figure 9. Volume resistivity vs time for three casting resins 71°C and 95% relative humidity.

TABLE 1

Temperature Coefficient, α, of the Resistivity and Resistivity, ρ at 25°C for various Casting Resins.

Casting Resin	Temperature Coefficient, α	ρ25°C ohm-cm
Thiokol-Epoxide	1.15×10^{-1}/°C	2.3×10^{11}
Polyamide-Epoxide	2.03×10^{-1}/°C	2.5×10^{16}
Filled Epoxide	1.12×10^{-1}/°C	$> 10^{17}$
Epoxide A	1.35×10^{-1}/°C	6.0×10^{15}
Epoxide B	2.56×10^{-1}/°C	$> 10^{17}$
Epoxide C	1.30×10^{-1}/°C	1.0×10^{17}

its temperature dependency, a second plot will be obtained having the same or a slightly increased slope, but displaced slightly toward higher temperatures. The additional cure is shown by the constant displacement toward higher temperatures, i.e., the difference between the two parallel plots, both having the same slope. Once complete cure is attained the final resistivity vs. temperature plot will be reproducible.

The temperature limitations of this method are dependent only on the resin(s) under study. The parallel plate electrodes can be used at temperatures as high as 230°C. In general the linear relationship of resistivity vs. temperature does not necessarily hold above 110°C. Also, above this temperature, the resin may start to degrade. In practice the temperature dependence of the resistivity of some resins has been determined at temperatures as high as 160°C.

The method which has been developed for determining the effects of elevated temperatures and moisture on the volume resistivity of a resin is very useful. The value of this test is that the size of the casting approximates (or can be made to approximate) the size of many castings containing moisture sensitive electronic components. Components are encapsulated to protect them from moisture damage; however, under conditions of high humidity and temperature, the life of an encapsulated moisture sensitive component is limited. Moisture will slowly pass through the resin to the component. Methods for estimating the life expectancy of components under these conditions have been lacking. The method described can be used to estimate the time a component may be expected to function under specific conditions of humidity and temperature and to aid in selecting the most suitable resin to protect valuable components from moisture.

The size of the casting is very important. Generally the smaller the casting, the quicker the completion of the determination. However, this method can be used to approximate smaller or larger castings as necessity dictates. For example, it may be required to study the effects of moisture upon a much larger casting which contains a moisture sensitive component. The electrodes are encapsulated in the casting in the actual mold which is to be used in the production of the casting. Thus the electrodes are serving as a moisture sensitive component and the life of the electronic device can be estimated. The amount of time required to complete an experiment of this type is a function of the size of the casting, the resin and the temperature. Usually it is preferable to continue a run until the volume resistivity becomes constant. As shown in Fig. 9, about 60 days are required, using the crosslinked epoxide resins and the small casting.

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Edited by Ernest P. Moslo
Moslo Machinery Company

MANAGEMENT VIEWS

Engineering Manpower Utilization

George P. Humfeld
Radio Corporation of America

George P. Humfeld received his B.S. degree in Chemical Engineering from Purdue University in 1937. He worked as a chemist in a non-ferrous foundry for five years after graduation, and then joined U. S. Rubber Co. as a rubber compounder during the war years. He joined RCA in 1946 as an engineer in the Record Compound group, and in 1947 was appointed group leader. In 1956 he was made manager of this group. In this capacity he is in charge of development work on thermoplastic molding materials and processes associated with the manufacture of phonograph records. He is a member of the Board of Directors of the Central Indiana Section of SPE and is Treasurer of the Section. He is also a member of the American Chemical Society.

The need for more engineering graduates from American colleges has recently become a major concern of all American industries. Many crystal balls have been searched regarding the anticipated shortages and only time will reveal the true answers. From a practical standpoint each industry must review the status of engineering groups, and investigate moves that can be taken to obtain better utilization of existing manpower to carry through the possible crisis years ahead.

From an engineering viewpoint, plastics companies will vary from small groups of one or two engineers to large research and development groups with thousands of dollars of test equipment and men of many skills and professions. Whatever the size, however, the objectives are the same, namely: to make the best possible use of engineers by increasing engineering productivity per engineering dollar spent.

Generally speaking, these men, whether mechanical, chemical or industrial engineers apply their knowledge and efforts (1) to maintain present production (2) to keep tooling methods and procedures up-to-date and to maintain same at minimum cost levels and (3) carry on research and development on new materials, methods and processes.

To carry on its program effectively the plastics industry must compete with other industries for engineering manpower. Its success will, to a great extent, be measured by the consideration given to, first, the professional status of the engineer, secondly, his economic status and third, his status within the company. These three phases of industry-engineer relations are the points that will be considered in more detail.

Professional Status

The development of the professional status of an engineer is something that can be fostered by management to the mutual benefit of both the employee and employer. The employer can contribute to this by making a careful analysis of job responsibilities and create adequate position titles to give the engineer the proper advantage to carry out his work effectively.

Professional societies have developed over the years to make it possible for men with common background and problems to get together and exchange information and ideas. Such experiences can aid greatly in enlarging the engineer's perspective and stimulating his thinking. Therefore, he should be encouraged in every way possible to take an active part in local and national professional societies.

Engineering projects often lead to the collection of data or the development of ideas which demonstrate the initiative and creative ability of the engineer. Engineering papers published through the technical societies are an excellent method in aiding the engineer to disclose his work when permissible. Therefore, wherever company policies will permit, the engineer should be encouraged to disclose new developments via technical society papers.

Last of all, the engineer should be helped in his rise in professional status by making it possible to obtain additional technical training. This can be accomplished in many cities by off-campus courses offered through the extension service of many of the large universities. In other cases campus short courses are offered which give specialized training usually in specific subjects. This phase of development for the engineer usually can be measured in terms of direct dollar returns to the company as the engineer develops in educational and practical experience so it should be encouraged by management.

Economic Status

Remuneration to the engineer is his best yardstick of determining his success in the world. From the

engineering utilization and supply standpoint it is tragic to train an engineer via education and practical experience to the point where he can really produce for his employer and then have him move from a truly engineering capacity to a production managerial position because increasing engineering opportunities are not available to him.

Therefore, planning should be such that engineers, once they are trained for their particular activities can have sufficient growth and development both economically and position-wise to insure that they remain in their engineering profession.

Company Status

The engineer has a long range stake in a plastics company's operations as he works on new and improved materials, methods and processes. To be well informed he must be kept up-to-date on over-all company objectives. Further, it is desirable to include him in long range planning programs to stimulate his thinking and increase his productivity. As mentioned under economic status, he must have room to grow in engineering within the company so that at the peak of his productivity he does not change over to production management positions because of greater opportunities.

Maximum engineering productivity can only be obtained when the engineer is adequately supported within his organization with subordinate facilities to make him most effective.

For example, he needs draftsmen to carry his ideas from sketch pad to detailed processes or products. Also included in his supporting staff are clerks and typists to aid in report writing, and the routine tasks of running an office. A supporting staff of this type will free the engineer, allowing him to spend his entire time on creativity and data analysis and interpretations aimed toward furthering a larger engineering program.

Such an ideal approach as outlined above is all inclusive in its concepts and cannot be adopted in its entirety by each member of the plastics industry. Modifications can be made to meet each individuals condition. In all cases, the hope is that more careful thinking by management will lead to the end result of increasing engineering productivity per engineering dollar spent.

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Studying the Electrical Properties of Casting Resins . . .

(*continued from page* 44)

An advantage of these methods is that many of the determinations can be made on the same casting, thus minimizing the work necessary to study the important electrical properties of a resin. If a single casting, is to be used, the determinations should be made in the following order using a small casting: Volume resistivity during adiabatic polymerization; volume resistivity after polymerization and post curing; volume resistivity as a function of temperature; the dielectric constant and dissipation factor; and the volume resistivity at 71°C (160°F) and 95% RH. If the volume resistivity at 71°C and 95% RH, as a function of time, is not to be determined, it is recommended that a large casting (2.6″ in diameter and 4.0″ high) be used. If it is desired to measure the volume resistivity during an isothermal polymerization using the special cylindrical electrodes, the cured sample can only be used for determining the volume resistivity as a function of temperature.

It has been observed that the liquid resin adheres to (wets) the electrodes before polymerization and also after polymerization is complete. It is often impossible to break the bond between the electrode and the solid resin. This bond reduces the contact resistance between the electrode and solid resin to a minimum. This is important because the contact resistance of the electrodes is rarely negligible (Ref. 6) and usually unknown, hence a source of error. Norman (Ref. 7) has shown that, when a resin is polymerized directly to a brass electrode, the contact resistance is so small that it cannot be measured.

The methods presented in this paper have the advantage over the ASTM method (D257-57T) in that the electrodes are completely encapsulated before polymerization takes place and all subsequent measurements are made using the encapsulated electrodes. This eliminates errors due to moisture and foreign matter. The values of volume resistivity obtained by this instrumentation, using the encapsulated parallel plate strip electrodes, compare very favorably with the values obtained by other methods.

Summary

In this paper the usefulness of the continuous current monitoring device is described and its use as a research tool and in quality control work discussed. With this device many of the important electrical properties of a casting resin may be determined, with a high degree of accuracy, on a single casting. These techniques can be used to determine the electrical properties of a resin under a wide variety of experimental conditions.

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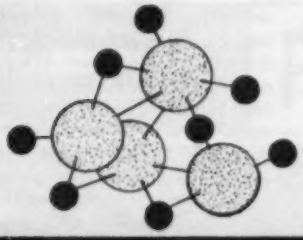


POLYMER SCIENCE

Current Problems In Polymer Science and Technology

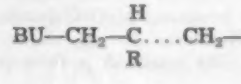
Dr. Herman F. Mark
Polytechnic Institute of Brooklyn

Synthesis

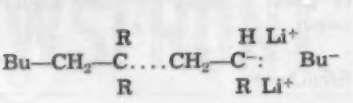
The capacity to prepare stereoregulated polymers has been considerably improved both with respect to the degree of stereoregulation and to the number of monomers which can be successfully brought into a regulated macromolecule. Closely controlled conditions in the preparation of certain Ziegler-Natta catalysts and of anionic lithium alkyl and aryl initiators have made it possible to obtain *cis*-polyisoprenes and *cis*-polybutadienes up to and beyond 95% *cis* structure and special combinations of titanium subhalides with aluminum alkyls have produced polypropylenes with similarly high degrees of isotacticity.

Non-hydrocarbon type monomers such as vinyl halides, acrylates and methacrylates have been obtained in stereoregulated, well crystallizable modifications and it is highly probable that catalysts will be found which are capable of stereoregulating the polymerization of all vinyl, acrylic, and allylic monomers. Several working hypotheses are used in order to arrive at such systems. One is the consideration that "good" Ziegler-Natta catalysts, which polymerize ethylene and propylene rapidly and up to high conversions, have too strong complexing capacity for polar monomers or dienes; the transition state complexes for the propagation reactions of such monomers are too stable and the catalysts are "poisoned." It appears, therefore, promising to explore the area of "poor" Ziegler-Natta catalysts—poor with respect to their capacity to polymerize ethylene or propylene —and to examine their activity for dienes and polar monomers. The "down grading" of the catalysts can be visualized and effected in several ways: it is possible to replace the highly reactive $TiCl_4$ by less reactive titanium compounds, such as TiI_4, $Ti(OR)_2Cl_2$ or TiR_2Cl_2, or to use V, Cr or even Fe as the transition metal component of the complex. One can also diminish the reducing capacity of the metal alkyl and use higher Al-alkyls, Al-chloroalkyls or complex Na, Al-Li, B-alkylhydrides and one can work at elevated temperatures and in solvents which influence the complexing capacity of the monomer. Using all these variables in appropriate ways it was possible to prepare high *cis* and *trans* forms of polybutadienes and polyisoprenes and stereoregulated polyacrylates, methacrylates and vinylhalides.

Another altogether different method of stereoregulating the polymerization of dienes, vinyl and acrylic type monomers is the use of lithium alkyls and aryls in homogeneous solution. Recent investigations indicate that the propagating chain end in such cases does not exist as an *ion pair* but is rather represented by an *ionic quadrupal* in which the alkyl or aryl component of the initiator plays an important role. Thus, in the polymerization of $CH_2{=}CHR$ with Bu Li the situation should not be depicted as



but rather as



This ionic quadrupal complexes with the monomer (eventually with the aid of a co-complexing agent or stereomodifier) and regulates its entry into the growing chain. High *cis* and *trans* polydienes and stereospecific acrylic and methacrylic polymers have been obtained in this manner with good yield and the proper choice of the different components of such systems promises further progress in this direction.

A new method for the synthesis of polyesters, polyamides, polyurethanes and other polycondensation type macromolecules consists of the reaction of aryl dichlorides with diols, diamines, diimines or other bifunctional monomers. Hydrogen chloride is split off and is neutralized by an appropriate acceptor. The high reactivity of the aryl chlorides causes the reaction to take place very rapidly even at ordinary temperatures and makes it necessary to control the rate of mixing of the two components in an effective manner. This is achieved by dissolving these components in two liquids which are not miscible with each other so that the reaction can only occur at the interface and is essentially controlled by the rate with which the two components can diffuse to the site of their interaction. The essential feature of this *interface* polymerization is that the reaction always takes place far from the polymerization equilibrium in contrast to the normal, high temperature, interchange type polycondensation processes which are carried out in the immediate neighborhood of the equilibrium. Hence interface polymerization approaches in its character addition polymerization, can operate at relatively low temperatures, can lead to products of very high molecular weight and of non-equilibrium molecular weight distribution and can be accelerated by increasing the reactive interface. It is possible with this method to synthesize polyesters, polyamides and polymethanes of very high melting points whereas the standard equilibrium procedure can only lead to very low molecular weights or cannot be applied at all. It was also possible to introduce into linear chain molecules such diimines as piperidin or substituted piperidines leading to very

high melting materials which are of great interest for fiber formation.

Structure

In the foreground of interest stands an adequate definition and experimental determination of the "degree of tacticity" of stereoregulated macromolecules. It is clear that the X-ray method is only capable of analysis in the domains of high degrees of order but fails as soon as the stereoregulated segments become so short that they cannot establish a three-dimensional lattice-like order over sufficiently large volume elements. Yet, there must be structural differences even within the range of the various "amorphous" species because there is a change of such properties as specific gravity, softening characteristics and solubility from sample to sample depending upon the exact conditions of its preparation. Several authors have developed statistical methods which describe, classify and characterize in an adequate manner the degree of tacticity in terms of the individual propagation rate constants for isotactic viz. syndyotactic addition with respect to the last and the penultimate member of the growing chain. They permit the calculation (or at least the estimation) of the average length of isotactic viz. syndyotactic sequences, the melting and solubility characteristics of the various intermediate species. Several different experimental methods are now under investigation to establish the "microtacticity" of chains in the state of overall random coiling, such as in an amorphous solid, in the melt and in a dilute solution. The first and second moment of nuclear magnetic resonance absorption lines as a function of temperature appears to give interesting information on the state of the local configurations in "semitactic" olefin polymers. In the case of stereoregulated vinyl- and acrylic ester polymers it was found that the initial rates of hydrolysis or other similar kinetic data depend in a striking manner upon the microtacticity in the sense that syndyotactic pairs of substituents represent a more stable condition than isotactic pairs. It is clear that systematic quantitative kinetic studies of this type will provide not only information concerning the local configurations in the chains but also on the attainable differences in reactivity as a result of different degrees and types of tacticity.

For a long time it was assumed that the conformation of vinyl type chains and also the conformation of the methylenic segments in polyesters, polyamides and polysulfides in the crystalline state was essentially that of a simple planar zig zag. Although this is true in some special cases it must be acknowledged that, in general, the chains are arranged as helices in the crystalline state and that even in the melt or in concentrated solution under certain conditions helicoidal conformations prevail over completely random coiling. This notion has led to the systematic study of helices which are capable of accommodating head-to-tail vinyl and acrylic type chains and can then be bundled up to form a crystal lattice. These helices are characterized by the number of monomers and the number of turns which are required to restore complete identity along the axis of the helix together with the absolute values (measured in Angstrom units) of the identity period and the effective diameter of the helix. The type of helix in which a given polymer crystallizes is essentially determined by the bulk polarity and polarizability of the substituent and by the mode of their arrangement—isotactic versus syndyotactic. Very interesting data have been collected on the transition of polypeptide type chains from the state of a regular helix to that of a random coil and statistical theories for the description and interpretation of kinetic and equilibrium measurements have been developed. These helices are so strongly stabilized by intramolecular hydrogen bonding that they exist even in very dilute solutions, where their exact size and shape can be determined from lightscattering and ultracentrifuge measurements and by observation in the electron microscope after the individual molecules have been deposited from the solutions on an electron microscope screen.

Application

Promising progress in the rubber field is made by the preparation and characterization of block and graft copolymers of vinyl and acrylics with natural rubber, GRS and polybutadiene. Many products of this type are prepared by "mechanical degradation" grafting during which free radicals are formed at the macromolecules of the elastomer by the breaking of C-C bonds through sufficiently strong shearing action. The method has been worked out to such an extent that one can prepare several pounds of the grafted elastomer (Hevea Plus) on a laboratory mill within one or two hours. The proportions of the vinyl or acrylic added can be conveniently varied from a few percent to several hundred percent. Grafting of acrylic esters and/or acrylonitrile improves significantly the resistance to solvents and the abrasive characteristics. An interesting general observation was made in the course of these studies; it indicates that even a small number (3-5%) of hydrogen bonding pairs of groups (CO and OH, CO and NH, CN and OH or NH) increases sharply the tear strength of the material.

Another area ready for application is the existence of a good synthesis of all *cis* polybutadiene and of copolymers of ethylene and propylene, ethylene and butylene and ethylene, propylene and butylene.

The best catalysts for the preparation of polybutadiene with a *cis* content above 85% are presently prepared by the reduction of $TiBr_4$, TiI_4 and titanium halo esters with such relatively mild reducing agents as triheptylsodium aluminum hydride and similar alkyls or mixed alky hydrides. Apparently it has been possible to increase the efficiency of these catalysts to such an extent that one can get several hundred pounds of polymer per pound of catalyst, which will make the *cis*-polybutadiene a very cheap elastomer. It is a soft, snappy, low modulus elastic material with high unsaturation and represents one extreme wing of the elastomer spectrum.

Copolymers of ethylene, propylene and/or butylene can also be prepared with high catalytic efficiency through the application of Ziegler-Natta-catalysts or Phillips Petroleum-Standard Oil of Indiana systems. The technology is reaching a high degree of perfection and these materials are also, in principle, very cheap and available polymers. They represent the other extreme wing of the elastomer spectrum because they are boardy and sluggish, have a high modulus, no unsaturation and excel by their abrasive resistance and by their reluctance to swell in organic solvents.

Systematic studies are now under way to find out how well these two extreme representatives of rubbery hydrocarbons can be blended with

(*Continued on page* 58)

CYANAMID

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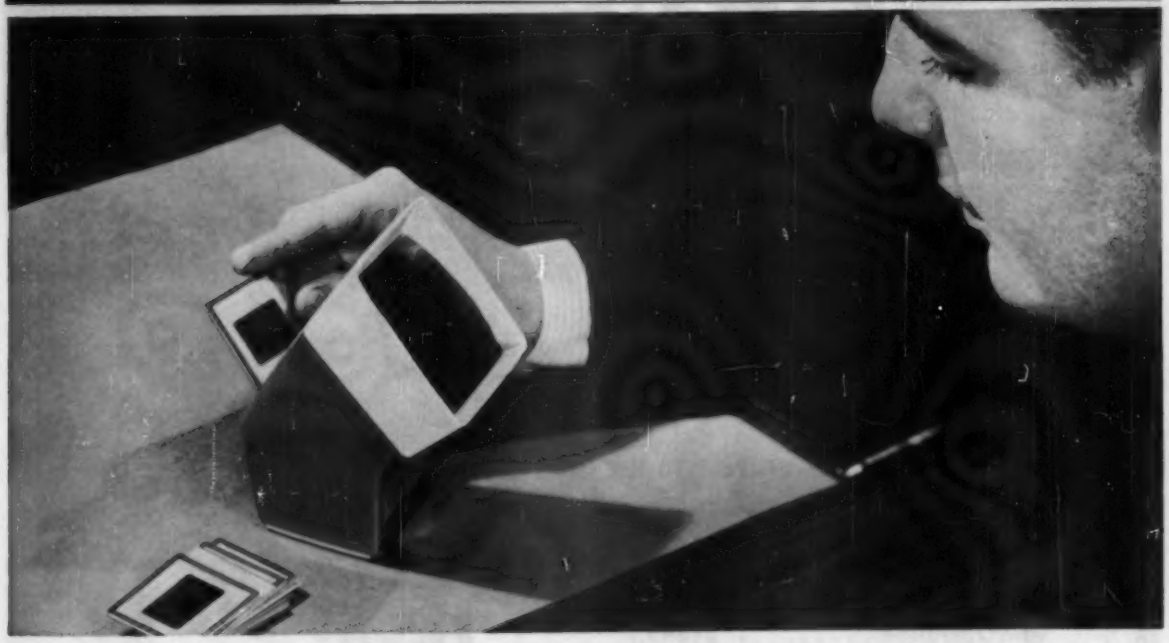

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MOLDING CYCLES

Flow Orientation in Injection Molding

Dr. H. B. Kessler
Sales Service Laboratory
Polychemicals Department
E. I. du Pont de Nemours & Co., Inc.

Flow orientation has been a problem since the introduction of injection molding resins. Except for special cases, however, it received little direct attention until recent years, when the use of plastics in applications requiring close control of dimensions and physical properties have forced the consideration of this problem. In many cases it has been of value to review the possible effects of flow orientation from the original considerations of part design to the final possibilities of post annealing.

Flow orientation is partial alignment or "stringing out" of the long molecules during flow of the molten plastics. Before flow begins the resin is a somewhat tangled mass of randomly distributed molecules, as indicated in Fig. 1A. As this melt is forced through a restriction such as a gate or a cavity, the arrangement of the molecules is distorted by the laminar nature of the flow. The material at the wall of the channel resists flow and moves very slowly, while the material in the middle of the channel moves much more rapidly. This shearing action causes the molecules to be somewhat "ironed" out in the direction of flow as indicated by Fig. 1B. They are not combed out completely like carded wool fibers, but retain many of their entanglements with strained molecules or segments of molecules between the entanglements. If the flow is stopped, the strained molecules relax back to a random orientation. However, if the material is frozen before most of the relaxation can take place, the molecules will remain strained. The presence of these strains reduce the form stability of the molded piece. Under prolonged or high temperature service these strained molecules will relax further causing warpage, excessive shrinkage in the direction of flow, and in extreme cases cracking of the part.

The amount of flow orientation in the final part is influenced by both the amount of orientation caused by flow and the amount of relaxation permitted before freezing the material. Let us first consider the factors which contribute to the formation of the orientation.

The amount of flow orientation induced during molding is dependent upon the properties of the resin in the melt state. A resin with higher viscosity will have greater orientation imposed on it than one of lower viscosity. The longer the molecules, the more serious will be the effect of flow orientation. In addition to the average size of the molecules or molecular weight, a broader molecular weight distribution will also make the problem more serious. A resin with the same flow index but broader molecular weight distribution will have a greater proportion of longer and shorter molecules than the resin with a narrower distribution. The shorter molecules have a lubricating effect, but this is not enough to overcome the slower relaxation of the very long molecules. Consequently the orientation of the longer molecules can be frozen in more easily with a resin of broader molecular weight distribution.

With a given resin, the molder can control the amount of flow orientation by controlling the temperature of the melt during flow. This means the temperature during the entire time that flow occurs and not only the temperature of the melt as it leaves the injection cylinder. Both the temperature of the mold and the rate of filling are of importance. If the mold is too cold, the polymer cools so rapidly that cold, highly viscous material must flow during the later stages of filling. Similarly, slow injection causes the same difficulty by giving the resin more time to cool as it flows. If the pressure is maintained and the gate remains open during the cooling of the part, serious orientation may result from the packing where the polymer may be solidified as it is still flowing. The use of weigh feeders and bottoming of the ram effectively eliminates the orientation due to packing flow.

Simple geometric considerations of size and shape of the mold cavity and the gates are also important factors which should be considered when designing the mold. Flow orientation will be more serious in thin sections than in thick sections, and will be more important for longer flow paths than for the shorter paths.

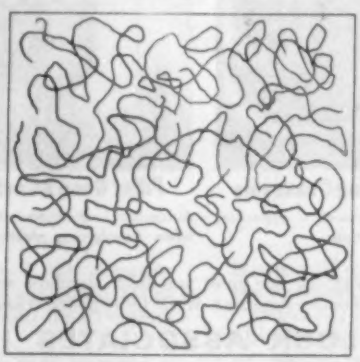

Figure 1A.

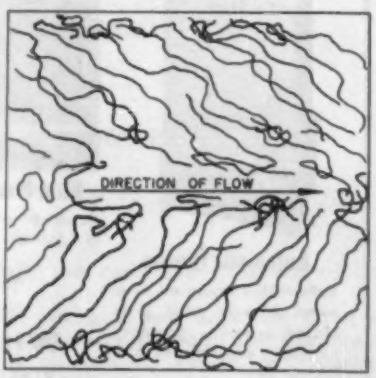

Figure 1B.

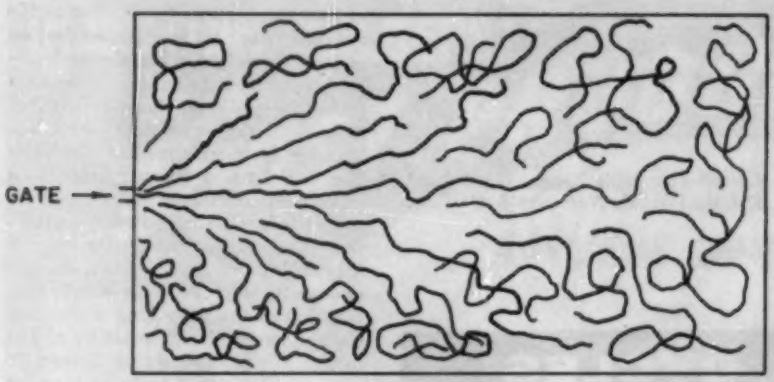

Figure 2.

The geometry of the final object is dictated by its intended use and the molder must employ proper design and location of gates to reduce the problem of flow orientation. This is most serious in the vicinity of the gate as indicated in Fig. 2. It is responsible for the dishing that often occurs at this point. Since shrinkage is greater parallel to the direction of flow, relaxation of the oriented molecules may cause sufficient non-uniform shrinkage to result in warping. In some cases, because of design, the molding resists warping and a crack may be formed. For example, in a center-gated container mold the flow lines in the bottom radiate out in all directions from the gate. Increased shrinkage in the direction of flow weakens the area around the gate and in extreme cases can even cause the bottom to crack. Since the properties of the part at the area near the gate are adversely affected, every effort should be made to locate the gate in a non-critical area.

The type of gate is also an important consideration. The amount of orientation is increased with increased length of the land and decreased diameter. Therefore, the gate should not be too narrow or too long. A flash gate or flared gate may be needed to provide a more uniform flow pattern and a more uniform shrinkage.

Annealing of the part can also be used to reduce the amount of flow induced strain. This generally means a post annealing process, but sometimes earlier removal of the part from the mold is sufficient. While in the mold, the part is being cooled very rapidly and the strains have little time to relax. If the part is ejected while still quite hot, the slower cooling rate in air results in some annealing. In some cases a hot quench can be used to further reduce the cooling rate.

Many of the efforts to decrease flow orientation are consistent with normal molding practices. However, in some cases, such as using higher melt temperature, they are in opposition to other important factors. Optimum conditions cannot always be selected, therefore it is necessary to compromise by considering the whole picture. Such consideration should begin with the original mold design and carry through to any post annealing steps required.

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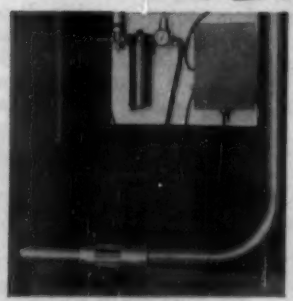

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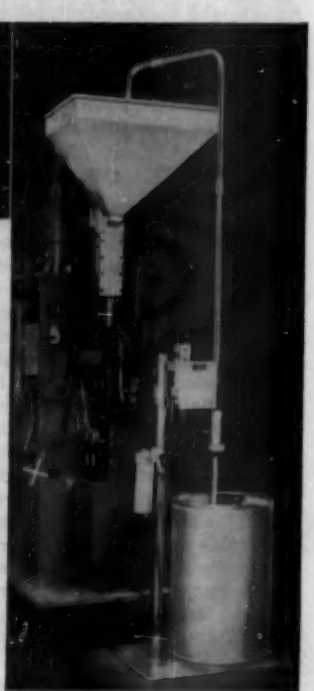

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Edited by R. D. Sackett
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SPEAKING of EXTRUSION

Drives for Extruders

Gordon D. Campbell, Jr.
Reliance Electric and Engineering Co.

In considering the various types of drives available for powering extruders, we have endeavored to define some of the reasons that variable speed is required. A few suggestions and conclusions are included at the end of this article.

One of the factors affecting production rates, is the die opening. The top limit of screw speed, for any one die opening, is governed by the rate of heat transfer from the barrel walls to the raw material, to bring it up to the melt or plasticized state. Mechanical working of the screw on the raw material also adds to this heat build-up. If, upon speeding up the screw, the temperature of the stock drops off, it is likely that a poorer quality product will result, although for raw materials with a wide melt index range, this is not necessarily true. Some materials, with narrow melt index ranges, would require the machine to be slowed down to again produce an acceptable extrusion. It is apparent, therefore, that the actual die opening and the necessary screen packing, are governing factors in deciding upon production rates. We all know that die openings can vary greatly for any extruder. In general then, on the same machine, using the same raw material, a small die opening would give an optimum output at a lower production rate, in lbs/hr, than a larger die opening. Also, we may note, that on the same machine, for the same die, two different materials would have two different optimum rates of production, because of their different viscosities. For example, it seems that the main limiting factors in running conventional polyethylene are, the cooling facilities available, and the take-away equipment. If stacking or packing is done manually, then the human being becomes the factor limiting production speeds. On the other hand, when running rigid vinyl in the form of pipe, then the heat transfer rate, and its control, become a limiting factor to production speeds. The L/D ratio has a lot to do with the rate of heat transfer to the stock. Vinyl can be handled at a rate dependent on the rate of heat absorption, commensurate with proper extruder design. The extruder manufacturers are continually increasing the efficiency of heat transfer rates from the barrel to the stock. However, as previously mentioned, some of the available horsepower is used up in mechanically working the material and consequently raising its temperature.

Thus, we see, there is a definite need for a drive, which will enable the operator to select different speeds on his machine. Depending upon the range of products, and the materials going through the extruder, this may be a wide range of speeds.

Definition of Objectives

It is appreciated that screw design, length of barrel, compression ratio, die design, temperature gradient along the barrel, heating of the die, and water cooling of the screw, among other things, are all very important factors contributing to proper operation, and each could form the basis for this article. However, the purpose of this article is to deal with typical variable-speed drives available, indicate some of their advantages and disavantages, make a few general comments and suggestions which seem appropriate after load testing of production extruders in several plants.

If we can assume that:

1. The screw used is of the proper design and compression ratio and is adaptable to the type of material being run;
2. The range of materials to be run on the extruder is fairly well defined;
3. The die being used is of proper design, in accordance with good practice as arrived at by experience;

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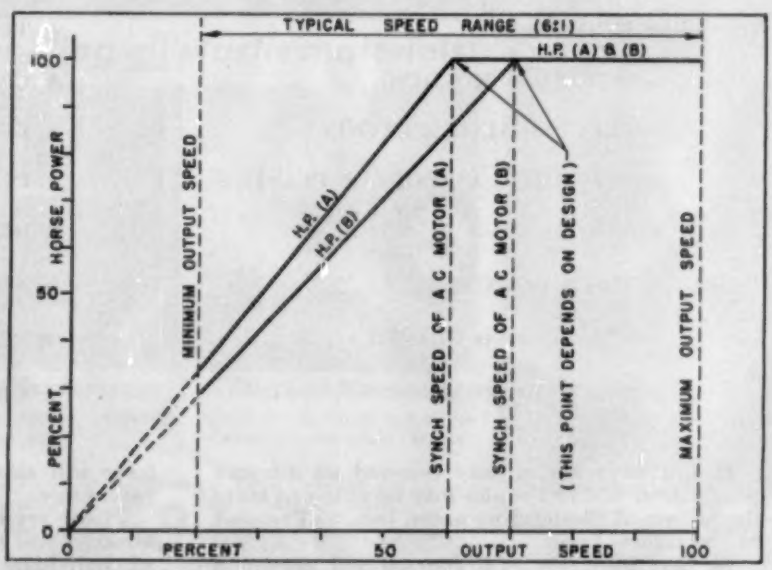

Figure 1. Typical horsepower-speed curves.

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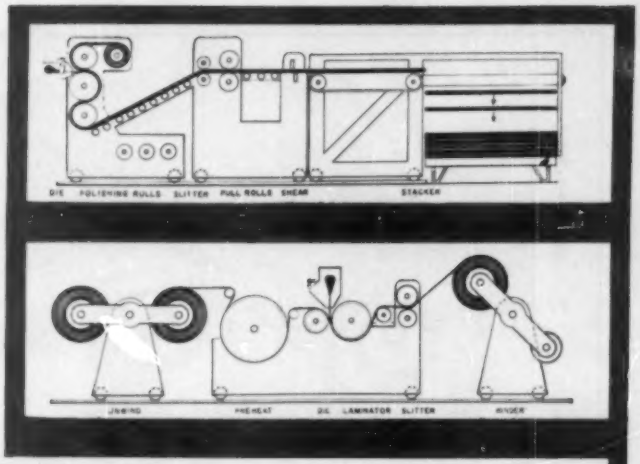

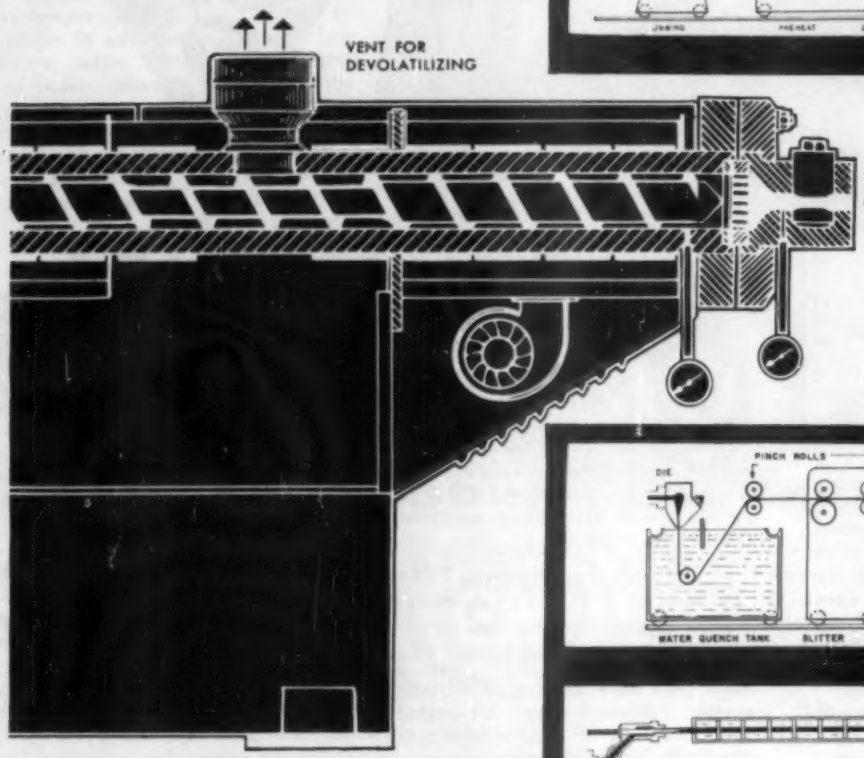

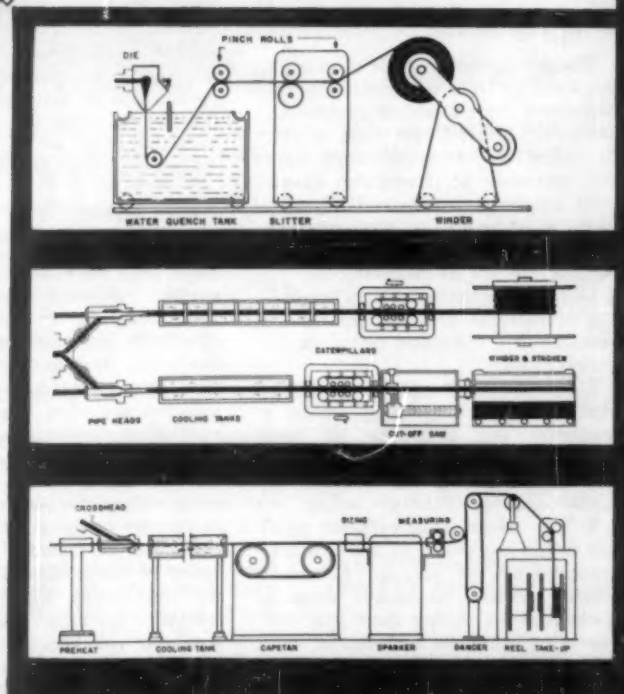

Designed for easier, more automatic operation and for faster capital return.

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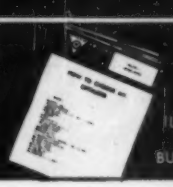
FORDS, NEW JERSEY · Hillcrest 2-2800

Manufacturers of Process and Extrusion Machinery

IN CANADA: Barnett J. Danson & Associates, Ltd., 1917 Avenue Road, Toronto 12, Canada



ASK FOR 50 PAGE ILLUSTRATED BULLETIN E-3

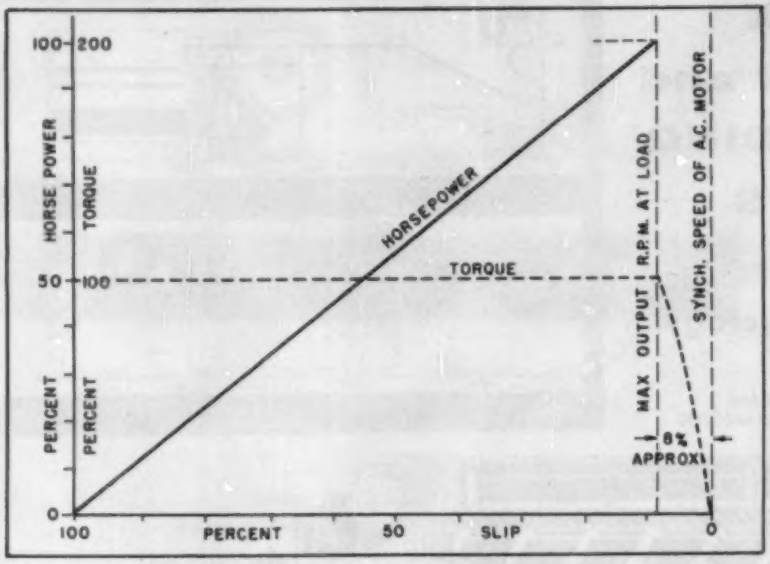


Figure 2. Typical torque-horsepower-slip curves.

Speaking of Extrusion . . .

(*Continued from page 54*)

then we can more easily get a clear picture of the drive requirements.

Drive Equipment

The drive must provide the torque required to turn the screw. In co-ordinated drives, where synchronization is required, one must be able to accelerate smoothly from rest, run smoothly at production speeds with good regulation, and in many cases, must be able to stop smoothly.

The three main drives offered to do this job are as follows:

1. The mechanical drive consisting of variable pitch pulleys and a standard a-c induction motor as the prime mover.

2. The electro-magnetic eddy current clutch, which operates on a magnetic slip principle to vary speed, depending upon the field strength. This unit is also driven by a standard a-c induction motor.

3. The all electric, variable voltage drive, consisting of a d-c motor mounted at, or on the extruder, which receives its power from a packaged d-c motor generator set, operating from an a-c source.

Mechanical Drive

The mechanical drive offers an inexpensive method of varying speed. Its variable diameter pulleys must be manually changed to change speed, unless remote control is added. Speed regulation is adequate, rarely exceeding 5%, but the speed range is limited to approximately 6/1. The complete unit sits at the input shaft to the extruder and requires more floor space, at the point of application, than the other two drives considered. Mechanical drives are most commonly sold for extruders requiring approximately 30 hp and below. There is no method of electrically synchronizing this drive to any other machine section, as is commonly required on a coating line drive.

Clutch Drive

The eddy current clutch offers a more expensive method of varying speed. Although the air-cooled clutch can slip to give zero output speed, its practical speed range is limited by its heat dissipating ability. For this reason, water-cooled clutches are often required. Remote control is standard equipment, and a feedback system can be added to give good regulation. The complete unit sits at the extruder, and requires probably a little less space than the mechanical drive, at the point of application. This drive can be electrically synchronized with another machine section, and is available in all horsepowers. On units above 75 hp, water cooling is required, although both air-cooling and water-cooling are available below 75 hp. However, for wide speed ranges, water-cooling is usually recommended.

As can be seen from Fig. 2, the eddy current clutch is basically a constant torque drive. In other words, horsepower is proportional to output rpm, and therefore rated horsepower is only reached at top rated speed. At half speed only one half of the input horsepower appears at the output shaft. The other half is dissipated as heat.

Variable Voltage Drive

The all electric variable voltage drive of the a-c/d-c variety, is the most versatile. It can provide a very wide speed range, can be regulated to 1/10 of 1%. It is more expensive and requires two pieces of equipment; the d-c drive motor, which applied at the extruder, takes up less space than either of the above two, and the packaged M/G set which can be placed on the floor, conveniently out of the way of production aisles. Remote control is standard equipment, and a feedback system provides excellent regulation. This type of drive can be electrically synchronized to any number of machine sections, as is required in co-ordinated drives. It is available in all horsepowers and provides for both a constant torque drive by variable voltage and a constant horsepower drive by weakening the field of the d-c motor. One recent market estimate indicated that more than 50% of the drives on extruders, were of this type.

To explain further the above comments, we can take a quick look at the Ward Leonard system, (Fig. 3), which is the basis for the d-c variable voltage drive. This system consists of a standard a-c motor, driving a d-c generator which powers the d-c drive motor. Varying the generator field strength, varies the output d-c voltage of the generator which is applied to the armature of the fully excited d-c motor. In this case, the speed varies with the d-c applied voltage. 8 to 1 is usable speed range below base speed (100%) and provides constant torque output for the d-c drive motor.

Now with full generator voltage applied to the d-c motor, if we are to weaken the motor field, then the motor speed increases still further. Here, the torque drops off, as indicated in Fig. 3, while the horsepower remains constant. Generally speaking, 4 to 1 or 400% base speed, which gives a total speed range of (8 X 4) =32 to 1, is the practical limit obtainable by field weakening; but special motors are built to operate

(*Continued on page 58*)

The

NEW

PRODEX

HENSCHEL

MIXER

THE NEW PRODEX-HENSCHEL MIXER

is used successfully in many installations here and abroad to prepare compounds ready for extrusion and molding, such as: **unplasticized rigid PVC dryblend, plasticized PVC dryblend, polyethylene colorant powder mix, cellulose acetate dryblend, PVC record compound, etc.**

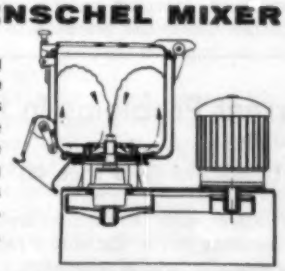
The PRODEX-HENSCHEL MIXER performs intensive dryblending and thorough dispersion of colors, pigments, fillers, stabilizers and/or plasticizers with plastics powders or granules.

It permits, if desired, the mechanical (frictional) heat-up of plastics powders faster and more uniformly than by conduction or radiation.

The unique principle of fluidizing dry powders so that they can be mixed like liquids, plus controlled shearing action, result in mixing quality and mixing speeds heretofore not obtained.

Design and Operation of the PRODEX-HENSCHEL MIXER

A cage-like ring of pins rotates concentrically around a stationary ring of pins. The rotating member also carries specially shaped blades and impellers which aerate and propel the powders to be mixed. The action is similar to that of a high-speed stirrer. The aerated powders or granules flow downward through the center of the rotating ring and pass through the zone of shearing between the rotating and stationary pins. The blend then moves upward along the wall of the mixing chamber. The entire batch rotates slowly around the axis of the mixing chamber. The rotating member of the mixing mechanism is usually operated at peripheral speeds of 100 to 200 ft/sec. The spacing between the rotating and stationary pins determines the shearing action. The shearing action controls mixing and dispersion as well as mechanical heat-up.



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Manufacturers of Process and Extrusion Machinery

ASK FOR BULLETIN M1

Speaking of Extrusion . . .

(*Continued from page 56*)

over a 6 to 1 field weakening range, a total range of (8 X 6) =48 to 1.

Practically all of the extruder manufacturers will provide any one of the above drives at the user's request. They all have their own recommendations on what horsepower is required to drive their machines. Very often this horsepower is a function of the size of the gear unit used.

Test Results

It has been noted while taking field tests, that except for cold start-ups and some slow runs on rigid vinyls, versatility was maintained. In some cases, the torque required to produce an acceptable product was below 50% of the torque available from the driving motor. Further it was noted that, with some exceptions, production runs were carried out below 50% of rated speed. In one case, three different materials—conventional polyethylene, acetate and styrene—were run on the same machine; all ran well below rated speed and rated load.

For a single purpose extruder, which is required to process only one raw material, a constant torque drive, if carefully chosen for speed range, will do the job satisfactorily. For a multi-purpose extruder, which is required to process several raw materials, the constant horsepower drive is more desirable, since it will handle the most difficult jobs requiring lower torques at higher screw speeds (conventional polyethylene).

It becomes apparent from the foregoing comments that choosing the correct drive for any one extruder is a complex matter. The user often wants the machine to be able to handle all commercially available raw materials, and also wants to be able to make innumerable shapes and forms with different dies. The machinery manufacturer is continually striving to provide the most versatile extruder of up-to-date design at a reasonable cost. All these requirements dictate that a drive be chosen to give a wide speed range, and often the drive appears to be overhorsepowered. However, as previously mentioned, the drive must have the overload capacity, when required, for certain operating conditions.

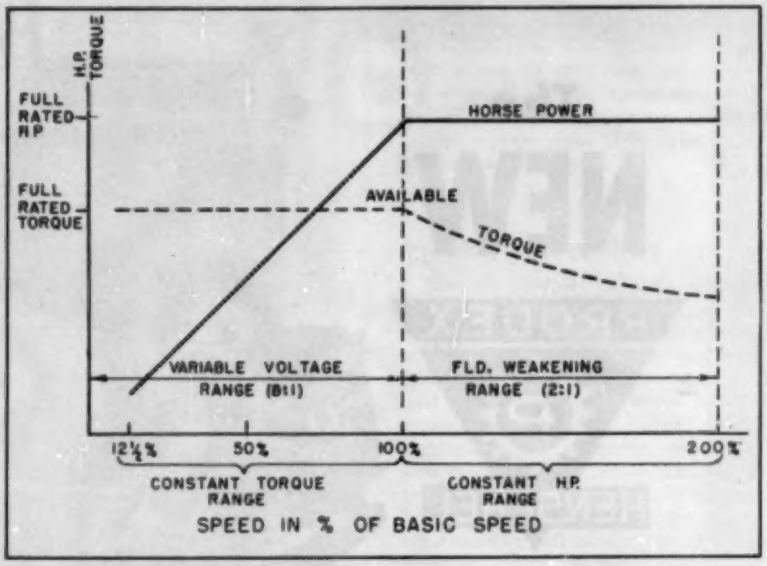

Figure 3. Typical torque-horsepower-speed curves.

A few suggestions on how to choose a drive are listed below:

The extruder user should make every effort to define the range of materials he expects to handle, *before* he purchases an extruder. The manufacturer can then better define what equipment should be supplied along with the extruder, such as take-away equipment, heating controls, the proper screw design for the job, and as herein discussed, the proper type and size of drive.

For simple straight through extrusions of profiles and shapes, where tolerances are not continually critical, the mechanical drive will do the job for a low first cost, but has disadvantages, such as limited size and limited speed range of approximately 6/1.

For co-ordinated drives such as wire coating line drives and extruder laminator drives, the all electric drive presents the most versatile approach.

Reliability of the driving equipment, its ease of maintenance when required, and availability of competent service assistance when required, should all be carefully considered.

★ ★ ★

Current Problems In Polymer Science and Technology

(*Continued from page 48*)

each other and by compounding and cocuring cover the entire range of practically useful elastomers. It seems that the tests have been very promising up to date and that compositions of practically all types of extensibility, modulus, Shore hardness and contractility can be made through appropriate blending and curing of these two extremes.

Since it is hard to see how, in the long run, cheaper raw materials can be visualized than ethylene, propylene, butylene and butadiene and since the techniques for their polymerization and the art of compounding is also primarily improved, it is believed that these two systems may become the cornerstones of rubber technology in the not too distant future.

The field of polycondensation type elastomers is also intensely cultivated with the exploration of particularly flexible "blocks" of the polyether and polysulfide type which have hydroxyl end groups and, can therefore, be expanded with diisocyanates and ultimately crosslinked with diamines, such as hydrazin, or ethylenediamine, with polyamines and carboxyacid anhydrides. Thiokol type blocks with reactive end groups lead to highly elastic, solvent resistant materials which can be spun into filaments, cast into fibers or processed into rubbery articles of all shapes.

★ ★ ★

Edited by Thomas A. Bissell
SPE Executive Secretary

NATIONAL ACTION

New Constitution and By-Laws

Like any constructive growing technical society, SPE periodically takes stock of its basic organizational principles and re-evaluates these documents to coincide with the changes fashioned by its progress. Three years ago the long and arduous task of revising our Constitution and By-Laws was started by the SPE Member best qualified to do the job, Wayne Pribble, Councilman from Northern Indiana Section, who has served for many years on the Constitution and By-Laws Committee; in 1957-1958 he was Chairman and is now Co-Chairman. He also functions as SPE Parliamentarian.

For a man to function properly on a revision of Constitution and By-Laws, he must thoroughly understand their function from all operating levels of the Society. Fortunately for SPE, Wayne Pribble had that background and he proceeded to delve back through all the necessary minutes of Council meetings to correlate proposals on which action had been taken, favorably and otherwise, until the history was complete.

At the 14th SPE ANTEC in Detroit, the 1958 National Secretary, George Martin, was assigned as Administrator of the Constitution and By-Laws Committee by President Ken Gossett. Ken also ordered an early deadline in which to conclude the revision and prescribed this work as one of SPE's major objectives for 1958. An active committee, comprised of George Martin, Wayne Pribble and Art Logozzo as members, and Ken Gossett and Tom Bissell as ex-officio members, held four lengthy meetings to finalize the documents. The By-Laws are now ready for final reading before Council in New York in January, 1959. The members' final decision on the Constitution will be made by letter ballot immediately after ANTEC.

One of the first decisions reached by the Committee was to separate the Constitution and By-Laws, which were integrated in the old printing. This will facilitate use as well as increase flexibility to local parliamentarians and to others. The many rules which were incorporated in former documents have been removed in their entirety and relegated to their proper position in the various procedures which eventually shall be included in the appendage.

The name of the Society was recommended changed but, after due process which included a complete survey, the present name was retained. The listing of the objective of the Society and how it shall be achieved was considerably streamlined, resulting in saving of much verbiage which was one of the main objects of the Committee.

Several important changes in membership classification rate an explanation. The term "Professional Member" was dropped due to considerable conflict over the misinterpretation of its original intent and the ever present confliction with state licensed professional engineers. "Senior Member" has been substituted in this category. "Life Member" has been eliminated and a "Distinguished Member" category will replace it. "Student Member" has also been added to fill a void in the all-important field of education. This will enable the many institutions of learning now giving courses relating to plastics science and engineering to obtain all the privileges of SPE for students, with the exception of voting, at reduced dues.

Some important changes have been made in the privilege calling for business meetings so that at least three Sections must now collaborate instead of confining it to one Section as specified previously. The quorum figures have been changed for the Annual Business Meeting from 25 to 50 in keeping with the numerical growth of the Society.

The ability to amend the Constitution has also been made more stringent and a petition must be signed by 50 instead of 15 members as written in the present Constitution.

The election date of National Officers has been changed to eliminate the "lame duck" aspects that have been in effect. The new election date will be within thirty days of October 1st so that officers-elect may have their committees ready to function in high gear immediately upon taking office in January.

The Professional Activities Groups section in the By-Laws was ap-approved by Council in January, 1958. The Publications section has also been revised to coincide with the new Publication Procedures.

Inasmuch as the Society is incorporated under the Laws of the State of Michigan, a thorough legal editing has been performed to insure conformity. The technical editing is in the hands of experts with a tremendous background in this type of work. After final approval by letter ballot and prior to final printing, the Constitution and By-Laws will be completely indexed.

Since it is impossible to discuss the numerous details and complexities encountered in this revision, this report is confined to a few pertinent points. Section autonomy, the preservation of which is so vitally essential for the success of any technical society, was stressed at all times by the members of the Committee. Needless to say, the National Council has done a tremendous job of overseeing this work and suggesting numerous changes as the job progressed.

It is the sincere hope of the Committee that this long and arduous task will meet with the wholehearted approval of all members to the extent that the letter ballot will not only meet a 100% response, but also a 100% approval.

Arthur W. Logozzo

Arthur W. Logozzo
Co-Chairman
SPE Constitution and
By-Laws Committee

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are all the name implies—and more!

Alsteele Granulators

ALSTEELE GRANULATORS handle the entire range of thermoplastics, whether the material be .001" film or 11"-thick chunk solids. Even the largest molded objects require no prior sawing. And ALSTEELE GRANULATORS cut polyethylene and vinyl so the bulk factor will approximate your virgin material.

For extra durability, the Granulator cutting chambers are *all steel* . . . for extra strength, the hardened forged rotor is machined from *all steel* . . . and for smooth, constant cutting the two large heavy duty flywheels are *all steel*. Heavy duty machines are *water cooled*.

To meet your every need in plastics reducing machinery—whether for beside-the-press operation or for heavy duty chunk grinders — ALSTEELE GRANULATORS come in 26 models ranging in size from 3 HP to 200 HP, with cutting chambers up to 5'.

WATCH FOR IT!

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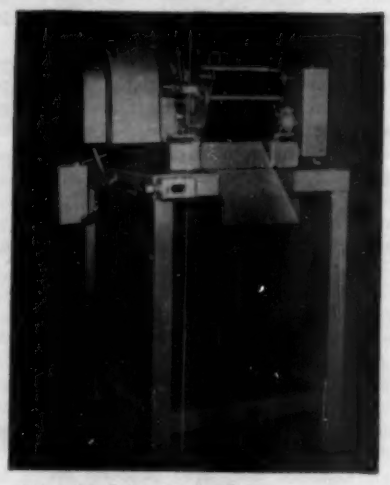
Alsteele Granulator: 100-150-200 HP

Beside-the-Press Granulators in a complete range of sizes

Alsteele Pelletizers

The Alsteele line of pelletizers works with extruders 2½" to 6" or larger. Instant synchronization with an extruder is made possible by the U.S. Varidrive. And ease of operation, maintenance and cleaning is insured by extremely compact design.

Additional features are excellent uniformity of pellets, and clean cutting action—even on elastomerics. A greatly lowered noise level is still another benefit.



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Detroit, Cleveland & Louisville: C. H. WHITLOCK ASSOC., 21655 Coolidge Hwy., Oak Park, Mich.

Pittsburgh Area: AUTOMATION EQUIPMENT & SUPPLY CO., 513 Empire Bldg., Pittsburgh, Pa.

In Canada: B. J. DANSON ASSOC., 1912 Avenue Rd., Toronto, Ont.

West Coast: EDMUND J. LYNCH, 2025 Martha Lane, Santa Ana, Calif

Annual Financial Statement of Society of Plastics Engineers

July 24, 1958

The Society of Plastics Engineers, Inc.
65 Prospect Street
Stamford, Connecticut

. . . I have examined the books and records of The Society of Plastics Engineers, Inc., for the period July 1, 1957 through June 30, 1958 and found them maintained in accordance with accepted accounting principles applied on a basic consistent with that of the preceding year.

Respectfully submitted,
Bruce Gordon
Public Accountant

SOCIETY OF PLASTICS ENGINEERS, INC.
STATEMENT OF ASSETS AND LIABILITIES
AS AT JUNE 30, 1958

ASSETS

Current Assets			
Cash—Fairfield County Trust Co.—Regular	$17,029.61		
Cash—Fairfield County Trust Co.—Special	628.49		
Petty Cash	100.00		
Total Operating Cash		$17,758.10	
Cash Reserved—First Federal Savings & Loan		17,982.27	
Cash Reserved—The Seaman's Bank for Savings		11,238.30	
Advances-Sections		350.00	
Advances-1959 Conference		1,933.47	
Accounts Receivable-Advertisers		4,638.23	
Inventory of Books and SPE Journals		5,387.74	
Total Current Assets			$59,288.11
Capital Assets			
Furniture and Fixtures			1.00
Prepaid Items			
Post Office Mail Deposits		372.53	
Rent Security		1,714.50	
Prepaid Rent		521.50	
Office Supplies		1,200.00	
Total Prepaid Items			3,808.53
TOTAL ASSETS			63,097.64

LIABILITIES AND SURPLUS

Current Liabilities			
Accounts Payable and Accrued Expenses	1,711.75		
Payroll Taxes Payable	1,550.94		
Total Current Liabilities			3,262.69
Reserves			
Contingency (Seaman's Bank for Savings-Contra)	11,238.30		
Research (First Federal Savings-Contra)	17,982.27		
Total Reserves			29,220.57
Surplus			
Balance—July 1, 1957	23,936.22		
Excess of Revenue Transferred to Surplus	6,678.16		
Total Surplus at June 30, 1958			30,614.38
TOTAL LIABILITIES AND SURPLUS			63,097.64

SOCIETY OF PLASTICS ENGINEERS, INC.
STATEMENT OF REVENUE AND EXPENDITURES
FOR THE YEAR ENDED JUNE 30, 1958

REVENUE		
Membership Dues		$ 59,451.37
Fees		11,497.00
Conference—1957		9,449.31
Conference—1958		26,957.43
Miscellaneous Publications		6,360.21
Interest and Other		1,058.05
		$114,773.37
Journal		
Membership Subscriptions		21,733.83
Non-Member Subscriptions		5,346.61
Advertising		77,016.79
Total Journal Income		104,097.23
TOTAL REVENUE		$218,870.60
EXPENDITURES		
Membership		14,562.72
Geographical Sections		36,459.05
National Committees		19,242.94
Plastics Institute Committee		228.09
Journal—National Office		22,201.34
Journal—Editorial Office		69,001.60
Other Publications		4,970.11
Conference—National Office (14th ANTEC)		10,651.79
General and Administrative		
Legal and Accounting		2,077.92
Postage		1,637.01
Telephone and Telegraph		2,016.59
Office Supplies		5,211.04
Office Rent, Light & Maintenance		8,360.05
Payroll and Miscellaneous Taxes		1,936.69
Insurance		248.58
TOTAL EXPENDITURES		$198,805.52
Excess of Revenue over Expenditures		20,065.08
Less: Transfer to Reserve for Contingency		357.90
Transfer to Reserve for Research		6,866.57
Capital Expenditures		6,162.45
		13,386.92
NET EXCESS REVENUE TRANSFERRED TO SURPLUS		$ 6,678.16

SECTION NEWS

Tri-State

Industrial Development In the Evansville Area

Bernard E. Higginson

J. E. Burris, of the Evansville Chamber of Commerce, was guest speaker at the first meeting of the new Tri-State Section held at the Hotel McCurdy September 15. He spoke on what the Chamber of Commerce has done and is doing to promote industrial development in the Evansville area.

Tri-State until recently part of the Kentuckiana Section, has elected H. E. Grossman President. Other officers are: A. S. Kothe, Vice President; H. H. Higginson, Treasurer; B. E. Higginson, Secretary; and William Utley, National Councilman.

The third Monday of each month has been set for the regular meeting day.

Kentuckiana

Cartridge Cases

R. O. Carhart

The first fall meeting was held September 24 at the Mason-Dixon Room, Louisville, with 21 members and guests attending.

A short business meeting was held at which time reports of the various committee chairmen and officers were heard. Section President Jack Berutich also pointed out that the section has lost one-third of its members as a result of the newly-formed Tri-State Section, and that extra effort should be made to enlist new members.

It was announced that Randy Carhart, Harold Cook and Bill Watkins had been selected to fill vacancies on the Board of Directors created by transfers to Tri-State. Daryl Hicks and Bill Watkins are Vice President and Treasurer, respectively. At the annual election these positions will be filled permanently.

Milo Buzzee, Program Chairman, introduced the speaker of the evening, Stanley Prosen of the Naval Ordnance Laboratory. Mr. Prosen talked on the development of a plastics cartridge case. His presentation covered the design, molding and testing of such a case, and was well illustrated by slides and a short movie.

Milwaukee

Polycarbonate Resin

James S. Hearons

The first meeting of the fall season was held September 17 at the Bavarian Club, Milwaukee. The dinner meeting started at 6:00 P.M. All future meetings will be held on the third Tuesday of each month at the same time and location.

There was a short business discussion. Section President Tom Hardeman gave information on future meetings, National Council activities and plans for the 1958-59 season.

The evening's speaker was William F. Christopher, manager of the Market Development Group of General Electric's Chemical Development Dept. He spoke on Lexan polycarbonate resin. The presentation dealt mainly with comparing Lexan's properties with those of other thermoplastics.

Southeast New England

Extruder Design

Glenn A. Tanner

The September meeting of the Southeast New England Section (formerly Rhode Island and Southeastern Massachusetts) was held at the Pawtucket Country Club with 113 members and guests attending. The principal speaker was Dr. Albert A. Kaufman, president of Prodex Corp., and chairman of the Technical Committee on Extrusion for SPI. He stressed the fact that extruder efficiency has increased greatly in recent years due to the use of proper instrumentation and improved screw designs. Of great importance is the designers' and operators' ability to get the horsepower from the motor through the gear train and the screw to the front end of the extruder.

Southern California

Injection Molding

John A. Stahmann

Over 100 members and guests attended the September meeting at the Section's new permanent meeting place, the Rodger Young Auditorium. The speaker of the evening was Lawrence A. Ulmschneider of Eastman Kodak Co., who has been speaking to various SPE Sections on "Automatic Injection Molding at Kodak Park." During the last 35 years Mr. Ulmschneider has concentrated on the design and manufacture of tooling for automatic production, and has specialized in guiding projects involving economical conversion to plastics parts for many of Eastman Kodak's products.

Toledo

Powdered Metals

R. E. Dunham

To open the fall session, the Toledo Section toured Republic Steel's Powdered Metals Division on September 17. The making of powdered iron for use in powder metallurgy resembles in many ways the production of plastics powders. Materials handling was also similar to that employed for plastics.

The formed metal parts made from this powder serve for some of the same applications for which plastics are being tried. However, possibilities of alloys, self-lubricating parts and temperature resistance make it difficult for plastics to compete in many applications.

Philadelphia

House of the Future

Ernest G. Schwab

The first meeting for the 1958-59 season was held at the Franklin Institute September 23rd. Two papers were presented.

J. R. Kent, of Monsanto Chemical Co., spoke on "Selecting the Proper Material." He stressed the joint responsibilities of purchasing, engineering and the customer.

T. DeMarco, also of Monsanto, discussed the "House of the Future," summarizing briefly the potential of plastics in building. His talk was accompanied by a film showing the engineering aspects and construction details for the house of the future along with a tour through the home.

Eastern New England

Perspectives on Russia

H. C. Cookingham

A dinner meeting was held September 23 at the Colonial Country Club in Lynn, Mass. Featured speaker was Dr. Robert E. Burk, associate director of research for Du Pont's Polychemicals Department.

Dr. Burk represented his company as a member of the U.S. Scientific Exchange team sponsored by the SPI in June. Illustrating his talk with slides, Dr. Burk told of his experiences and observations in Russia.

New York

Plastics in Russia

Charles C. Orr

The New York Section's first fall meeting was held September 17 at the traditional gathering-place, the Governor Clinton Hotel. More than 150 members and guests heard SPE National President R. Kenneth Gossett review the Society's recent progress. Following Mr. Gossett's talk, Clinton W. Blount, Bakelite Co., spoke on "Plastics Fabrication in the USSR." He discussed the Russian technical worker, labor management and the various plants that he visited; he augmented his talk with color slides taken in Russia during the recent SPI tour.

"Costing for Injection Molders" was covered during the second half of the general meeting by William Nussbaum, who has devoted himself to plastics costing since 1925. He outlined this phase of business beginning with the blueprint, and traced through estimate-recording to the profit-loss statement.

The Vinyl Sub-Group enjoyed a plasticizer forum, moderated by Dr. Irving Skeist, Skeist & Schwartz Laboratories. Members of the panel included Dr. Wesley D. Schroeder, Pittsburgh Coke & Chemical Co., and Arthur C. Hecker, Argus Chemical Corp.

New York's REPPAG gathered to see two Navy Department training films on reinforced plastics, which were presented by I. Reznick, Materials Laboratory, N.Y. Naval Shipyard, Brooklyn, N.Y. The first film was on inspection and quality control, and described inspection procedures for glass-polyester laminates. The second film, aimed primarily at shipyard workers unfamiliar with reinforced plastics repair, detailed methods of repair using glass cloth and epoxy resin systems.

The Thermoforming Sub-Group was addressed by A. J. Falkin, Metalmold Forming Co., who covered plaster, wood, phenolic, epoxy, aluminum, and spray-metal molds. Each type was shown to have a place, choice depending largely on the length of the run, labor consideration, and quality of the end-product. One of the big advantages of the spray-metal molds is its built-in cooling system, which follows the complexities of the mold pattern. Consideration was given to the possibility of forming smooth blisters with a rough mold by heating higher with shorter cycles. This forms an air-vacuum cushion. Mr. Falkin displayed both molds and finished items.

Detroit

Plastics for the Auto Industry

Frank S. Marra

The 1958-59 season was launched September 12 and 13 at the Section's fourth RETEC covering "Plastics for the Automotive Industry." A panel discussion on "How to Get More Plastics into Automobiles" and six technical papers on related subjects were presented to over 300 members and guests.

National President R. K. Gossett, National Publications Committee Chairman Eugene Quear and Executive Secretary T. A. Bissell spoke at the luncheon on Friday. At the banquet Friday evening, M. F. Garwood, chief engineer of Chrysler's Engineering Materials Div., spoke on "Periscoping Plastics Potential."

Saturday was devoted to the annual fall golf outing at the St. Clair River Country Club, followed by a cocktail party, dinner and dance.

Central New York

Electrical Insulation

Frederick E. Ruhe

The first fall meeting was held September 11 at Drumlins Country Club in Syracuse. Section President Jim Lampman brought the 32 members and guests up-to-date with SPE news, business and correspondence. He emphasized that each member should take an active part in the promotion of interest in plastics education.

Speaker of the evening was Dr. H. H. Rudoff of the Organic and Polymer Dept., General Electric Co. His talk covered electrical insulation and the adaptation of plastics to fit almost any requirement. Samples of motor parts were displayed to show the progression in overcoming certain insulation problems.

Western New England

Plastics in Packaging

C. Judd Holt, Jr.

On October 1, 200 plastics and packaging engineers participated in the Section's first Regional Technical Conference, "Plastics in Packaging." They ignored an all-day downpour and turned their backs on the opening game of the World Series to attend RETEC sessions at the Statler-Hilton Hotel in Hartford, Conn.

The luncheon speaker was Frederick S. Leinbach, executive vice president of Riegel Paper Corp. Nine

other speakers contributed technical papers to the program.

Telling his audience that the recession is ended, Mr. Leinbach urged adoption of a three-dimensional picture of the 1960's—dreams, designs and deliveries.

National Officers on hand for the RETEC included R. Kenneth Gossett, President; George W. Martin, Secretary; G. Palmer Humphrey, Treasurer; and Thomas A. Bissell, Executive Secretary. Mr. Martin, who is a member of the Western New England Section, served as master of ceremonies for the luncheon.

Upper Midwest

Mold Selection

Russell B. Kirby

The first meeting of the season was held September 15 at the President Cafe in Minneapolis. This will be the regular meeting place for the coming year.

A record turnout of 63 heard John Kavanaugh of Standard Tool Co., Leominster, Mass., discuss "Molds for Automatic Molding." The highlight of the evening was the cross-examination of the speaker on the subjects of beryllium copper in molds, cast steel hobs, and new mold casting methods.

Baltimore-Washington

Behavior of Plastics At High Temperatures

Taylor E. Birckhead

SPE National President R. K. Gossett and Executive Secretary T. A. Bissell spoke at the September 9th meeting to acquaint the membership with the National Organization.

Technical speaker of the evening was Lawrence H. Shenker of General Electric's Aerosciences Laboratory. He discussed the behavior of plastics at extremely high temperatures. Mr. Shenker has conducted extensive tests on reinforced plastics at temperatures of 20,000°F and at high velocities where most metals simply disappear. He has entered into a study of materials for the nose cone of re-entry missiles. Glass reinforced phenolics show fairly good properties for this application, but nylon cloth reinforcement in 57 percent phenolic resin seems to be better since the reinforcement is more compatible.

Chicago

Valve Gating of Injection Molds

Joseph H. Schmidt

The Chicago Section met September 8 at the Western Society of Engineers Building. The speaker of the evening was Albert Spaak of W. R. Grace and Co. He presented a talk on "Valve Gating of Injection Molds."

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TECHNICAL MEETINGS CALENDAR

15TH ANTEC

WORLDWIDE ADVANCES IN PLASTICS—January 27-30, 1959, The Commodore Hotel, New York City. Sponsored by the Newark and New York Sections. For more information, see page 53.

1959 RETECS

PLASTICS IN THE SHOE INDUSTRY—April 21, 1959, St. Louis, Mo. Sponsored by the St. Louis Section. For information write to Robert S. McDorman, Plastics Molding Co., 4211 N. Broadway, St. Louis, Mo.

PLASTICS IN THE METAL INDUSTRY—May 7, 1959, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by the Pittsburgh Section. For information write to John Parks, Hydraulic Press Mfg. Co., 512 Empire Bldg., Pittsburgh 22, Pa.

PLASTICS FINISHING—October 18, 1959, Niagara Falls, N.Y. Sponsored by the Buffalo Section with the cooperation of the Plastics Finishing PAG. For information write to Gordon K. Storin, 3 Forest Rd., Lewiston Heights, Lewiston, N.Y.

VINYL PLASTICS—Autumn, 1959, Cleveland, Ohio. Sponsored by the Cleveland-Akron Section. For information write to W. D. Martin, 12333 Chippewa Rd., Brecksville, Ohio.

SECTION MEETINGS

BALTIMORE-WASHINGTON—November 18, 1958, Langley Park Hot Shoppe, Washington, D.C. D.S. Ballentine of Brookhaven National Laboratory will speak on "Advances in Graft and Block Copolymerization."

PHILADELHIA—November 25, 1958, The Franklin Institute, Philadelphia, Pa.

* * *

Six Fall RETEC Preprint Books Available

Preprint Books of all six Fall RETECS are now available from the National Office:

1. "Plastics in the Automotive Industry, Detroit Section, 6 papers. $2.00, members; $3.50, non-members.

2. "Plastics in Packaging," Western New England Section, 9 papers. $3.00, members; $4.50, non-members.

For information on papers published in the above books, see SPE Journal, August 1958, pages 45 and 47.

3. "Epoxy Resin Symposium." Upper Midwest Section, 10 papers. $3.00, members; $4.50, non-members.

4. "Plastics in Electronics," Golden Gate Section, 8 papers. $3.00, members; $3.75, non-members.

5. "Advances in Injection Molding," Philadelphia Section, 6 papers. $2.00, members; $3.00, non-members.

6. "Plastics Trends in Building and Construction," Southern California Section. $3.00, members; $4.50, non-members.

For information on papers published in the above four books, see SPE Journal, September 1958, pages 65, 67, 68 and 71.

Other technical volumes also available from the National office are:

ANTEC Preprint Books

Vol. IV, 1958, Detroit, 94 papers. $5.00, members; $7.50, non-members.

Vol. III, 1957, St. Louis, 60 papers. $5.00, members; $7.50, non-members.

SPE Engineering Series

Vol. I—"Quality Control for Plastics Engineers," Dr. L. M. Debing. $3.98, members; $4.95, non-members.

Member rates are also extended to individual members of SPI. When ordering, please state whether you are a member of SPE or SPI. Books will be mailed postpaid if money is enclosed.

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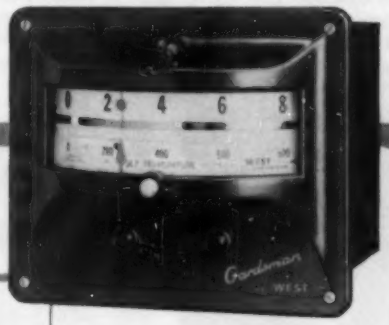

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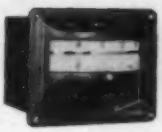

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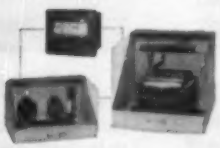

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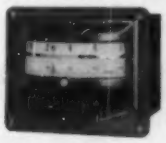

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ABOUT MEMBERS

R. Kenneth Gossett, SPE National President, spoke at the University of Wisconsin's Engineering Institutes Conference, "Beyond the Horizon in Plastics," held October 9 and 10. Mr. Gossett's paper is titled "The Plastics Engineer in Modern Industry." A graduate of Purdue University, he is president of Gossett and Hill Co., in Chicago. Since joining SPE in 1947, he has served in many capacities. At present he is Councilman-at-Large and a member of the National Executive Committee. He is affiliated with the Chicago Section.

R. K. Gossett

D. F. Behney

Dale F. Behney has been made executive vice president of Harwick Standard Chemical Co. A member of the Cleveland-Akron Section of SPE, he has been vice president in charge of sales and a director of the company since 1956.

Nicholas T. Baldanza, Newark Section, has been engaged by Arnkurt Association Engineers as assistant to the president, **Curtis F. Pearl** of the New York Section. His duties will include management, sales development and supervising of engineers. His previous experience includes: Curtiss-Wright, Plastics Division, chief engineer; Einson-Freeman Co., supervisor of research, experimental work and production; Hassenfeld Bros., supervisor of design, development and tooling. Mr. Baldanza has also maintained his own consulting engineering office for product research and development in Clifton, N.J.

Edwin Y. Wolford was chosen Salesman of the Year at the annual sales conference of Koppers Co., Inc., Plastics Div. Mr. Wolford is manager of Plastics Technical Service for Koppers, and is a member of the Pittsburgh Section.

Milton W. Bloom has assumed operation of Robinson Industrial-Crafts Ltd. as vice president and general manager, and has served his association with Reliable Plastics Co., Ltd. Mr. Bloom is a member of the Ontario Section of SPE.

Dr. Edward T. Severs has joined the product development staff of Sun Oil Company's Research and Development Div. Dr. Severs has specialized in the development, production and sales engineering of plastics products and resins. For the past three years he has been technical director of the Natvar Corp. Prior to that he worked under the Bakelite Fellowship at the Mellon Institute, and with Rohm and Haas and Atlas Mineral Products Co. He has had many articles published on the rheology of plastics. He is a member of the Newark Section of SPE, the American Institute of Chemical Engineers, the Society of Rheology, Technical Societies Council of New Jersey, Sigma XI and the Conference on Electrical Insulation of the National Academy of Sciences.

Jacque R. Smith has recently become technical sales representative for Bakelite Co. His new assignment will include the sale of molding materials and customer service in western Massachusetts and northeastern New York. His headquarters will be in Hartford, Conn. Mr. Smith graduated from Lehigh University with a B.S. in Mechanical Engineering in 1957. Prior to his present appointment, he completed an intensive training program with Bakelite in New York and Bound Brook, N. J. He is a member of the Western New England Section of SPE.

E. S. Marsh of the Chicago Section has been named district sales manager in the Chicago area for Plax Corp. Mr. Marsh has been with Plax as a sales representative since 1942. He previously worked for Hamilton Standard, Div., United Aircraft Corp. He is a graduate of Western Reserve University.

William A. Suiter, who recently joined Marbon Chemical, a division of Borg-Warner, is sales manager for Cycolac, and ABS thermoplastic resin. Mr. Suiter comes to Marbon from a sales management position with the Panelyte Div., St. Regis Paper Co. He is a member of the Miami Valley Section of SPE.

W. A. Suiter

V. L. Erlich

Dr. Victor L. Erlich, a member of the New York Section, has been elected vice president and director of basic research and development of Reeves Brothers, Inc. Dr. Erlich, who received his doctor's degree in chemical engineering from the Institute of Technology in Vienna, joined Reeves Brothers, Inc., in 1950 and later became director of research for the company's plastics division. Prior to 1950, he was an independent chemical consultant specializing in polymer technology. In his earlier career in Europe, Dr. Erlich was chief chemist and technical director of several chemical plants.

Edward B. Burstein of the Baltimore-Washington Section is co-author with W.W. Staley of a paper "The Effects of Temperature and Humidity upon the Electrical Characteristics of Printed Circuit Laminates." This paper will be presented at the Third EIA Conference on Reliable Electrical Connections, December 2 through 4, Dallas, Texas. Mr. Burstein is responsible for the development and evaluation of printed circuit materials and processes at the Air Arm Div., Westinghouse Electric Corp., Baltimore.

Louis B. Allen, Philadelphia Section, has joined the Plastics Laboratory of the International Business Machines Corp. in Endicott, N.Y. He was formerly associated with International Resistance Co.

James E. Parkhill joined Barnett J. Danson and Associates, Ltd., on November 1 as vice president. From 1945 to 1954, Mr. Parkhill was associated with Canadian General Electric Co. In 1954 he joined Rainbow Plastics, and moved to Smith and Stone, Ltd., when the custom molding division of Rainbow was sold to that company. He is affiliated with the Ontario Section of SPE, and is a member of SPI.

Richard B. Bender announces the formation of the Tejas Plastics Materials Supply Co., Fort Worth. He was formerly with Plastics Engineering and Sales Co. An affiliate of the North Texas Section of SPE, Mr. Bender is also chairman of the North Texas Section of the American Society of Corrosion Engineers.

Alfred Wittersheim and **Hans Hoeper** announce the completion of their new plant at 4551 W. Diversey Ave., Chicago, Ill. The company, Micron Specialties, is devoted to diamond polishing of plastics molds. Both men are affiliated with the Chicago Section of SPE.

Melvin Hare is chairman of a committee established by the North Texas Section to study the possibilities of sponsoring a seminar for engineering schools and high school seniors in the Dallas-Fort Worth area on behalf of plastics engineering education. Other members of the committee include **Richard A. Jenkins**, National Councilman, and **Ray Uber.**

Julian J. Lanza will be manager of the new sales office of Gering Products, Inc., located in Holden, Mass. The new office has been established to serve the New England area. Mr. Lanza, an affiliate of the Newark Section of SPE was formerly associated with Gering's main office in Kenilworth, N.J.

OBITUARY

Julian S. Pruitt, 33, chemical sales representative for Plastics and Coal Chemicals Div., Allied Chemical Corp., died August 28 after a short illness. Mr. Pruitt had represented Allied's Barrett Div., from which the Plastics and Coal Chemicals Div. was recently formed, in the Cleveland area since March 1957. Prior to that time, he was Barrett's chemical sales representative in the Detroit and New Jersey areas. A graduate of South Carolina State College, Mr. Pruitt was a member of SPE's Detroit Section, The American Society of Chemical Engineers, and the Chemical Salesmen's Club of Cleveland.

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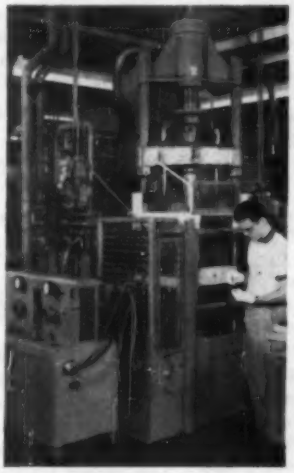

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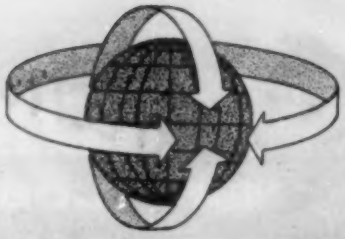

PLASTICS AROUND THE WORLD

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UNITED STATES

ELECTRICAL MANUFACTURING

August, 1958

Abstracter: W. A. Kelley

Super-Thin Bonded Insulating Films —W. K. W. Chen and W. E. Estey

The advent of transistorized circuits has brought about a remarkable reduction in the size of electronic equipment. The ultimate in miniaturization (essential for high velocity airborne equipment) can be attained only with thin dielectric films which will permit smaller coils and capacitors.

This article discusses methods of construction and evaluation of bonded insulating films for extremely small capacitors. The films discussed are Teflon, silicone and Formvar. The same techniques are shown to be applicable to foil coil transformer construction. The tables and graphs included show effective areas of electrical capacitance, dielectric properties and structural strength of the films.

★

RUBBER AGE

August, 1958

Abstracter: James Harrington

Polyurethane Foams—H. K. Frensdorff

The foaming behavior of polyurethane foams was investigated through the use of non-polymerizing model systems based on polytetramethylene-ether glycol (molecular weight 3000). This paper reports the conclusions of these studies.

The author also made gas permeability measurements which showed why the use of a carbon dioxide atmosphere prevents the shrinkage of foam during its cure. Polyurethane foam is 10 times more permeable to carbon dioxide than air and thus the substitution of carbon dioxide in place of the air ambient prevents the formation of a pressure differential before the foam is cured.

★

FRANCE

INDUSTRIE DES PLASTIQUES MODERNES

July-August, 1958

Abstracter: Hans Mayer

Impregnation of Canvas Hose by Means of Extrusion—

A method of coating a canvas hose inside and outside by means of extruding, thus transforming it into an object having the physical qualities of the plastic material chosen for the impregnation process, is described. Suitable materials and the attachments to the extruder are discussed.

Plastics for Gardening in the Sahara —M. Chouard

The use of plastics materials for agricultural purposes in the Sahara region is discussed. These will take their place in the distribution of the available moisture supply, in the conservation of moisture, and the protection of the growing crops.

Advantages of Infra-Red Heat in Curing Polyesters—H. Brendel

Temperature and moisture variations influence the setting and curing of polyesters to the extent that exact control of production cycles and quality are adversely affected. A fixture for proper exploitation of the elements of infra-red heat in this connection is described.

★

GERMANY

KUNSTSTOFFE-RUNDSCHAU

June, 1958

Abstracter: Leo Fischer

Adhesion for Metals—O. Schwarz

Groups of adhesives are discussed such as the formaldehyde condensation products — phenol, resorcinal, urea and melamine. Another group is the double bonded macromolecular compounds which have a linear chain reaction such as vinyl acetate, vinyl chloride, methacrylates, and styrenes. These are not too useful as adhesives, except as additives in condensation resins. Polyurethanes and epoxies are then mentioned.

Adhesion requires electromagnetic forces or polarity in a state where polarity is asymmetric. The resinous film on metals must be extremely thin for this reason. The adhesive must also have good wetting properties and should, preferably, attain a very low viscosity at initation of reaction, if only for a few seconds.

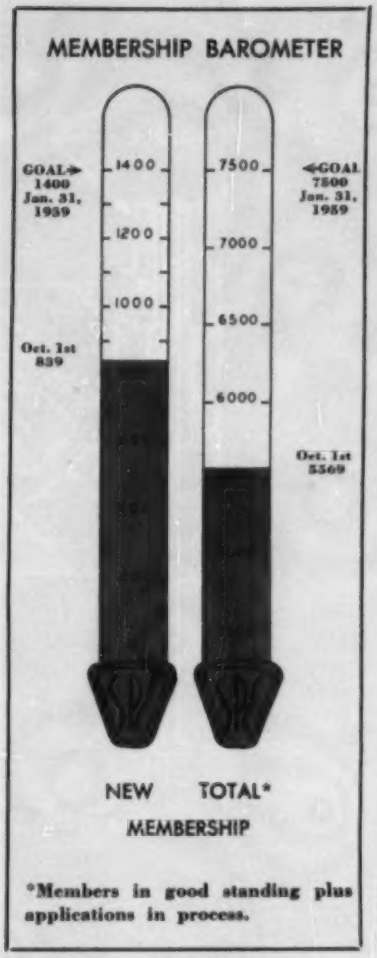
Wood Gluing with Synthetic Adhesives — Hans Kolb

This article discusses the basic principle of wood gluing and the various synthetics used such as ureas, phenols and melamines. The various structures, forms, beams and girders are illustrated and their construction described. Of special interest are the large curved laminates. Column-free areas of 43 m by 60 m have been built with wood laminate trusses and curved girders. Loads per girder of 44,000 kg have been attained.

Development of the Chemistry of Epoxies — Dr. Alfred Max Paquin

Switzerland seems to be the cradle of epoxies. Dr. Pierre Costan made the first successful attempt to create a hard resin with the ethylene oxide groupe, using 4, 4' dioxydiphenylpropane with epichlorhydrin. His patent was granted August, 1938 (Swiss P 211,116). It is interesting that the firm for which Dr. Costan worked dropped the project since they saw no use for it. Ciba subsequently acquired a license. The first commercial epoxy came on the market in 1948.

The chemical development of epoxies took place in the following



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direction: 1. Esterification or etherification of the polymer bisphenol A glycerol ether. 2. Substitution of bisphenol A by other bifunctional compounds. 3. Use of special hardening agents. 4. Combination of epoxy with other reactive resins or chemical compounds. The article gives a detailed history of these developments, citing individuals, firms and patents.

★

KUNSTSTOFFE

June, 1958

Abstracter: Charles S. Imig

Pre-Treatment and Printability of Polyethylene—Dr.-Ing. W. Kühn.

The various methods of treating polyethylene film are reviewed and described in great detail. Equipment for use is described so that all considerations may be covered before deciding which to use. Silk screening, gravure, letterpress, and aniline printing techniques are discussed in the light of their use with polyethylene.

Physical Properties of Monomeric Acrolein and Some Polyacroleins—Privat-Dozent Dr. Rolf C. Schulz

The physical properties of certain polyacroleins are compared with other vinyl polymers. Investigation of molecular refraction and infrared concerning the main structural elements agrees with the formula derived for chemical reactions.

Covering Wooded Surfaces with Rigid PVC Sheet—Dr. Carl Kubitzky

Extremely durable, colorful and hardwearing surfaces can now be produced by covering plywood and composition boards with rigid PVC by using suitable adhesives and bonding methods. The thermoplastic nature of the rigid vinyl allows its use in covering smooth as well as uneven or curved surfaces.

Report on the 1957 Activities of the German Technical Standards Committee (FNK)—Dr. A. Höchtlen and Dipl.-Ing. G. Ehlers

Following the report on the activities during 1956 as well as those of the preceding years, this is a report on the new developments in the plastics sector.

Pneumatic Feed Devices for Granulates—Dr. W. Paul

A review of pneumatic feed devices used throughout the world for feeding injection molding machines and extruders is presented. These devices are essential with large presses and contribute to the efficiency of any shop.

The Production of Porous Leathercloth—Dr. Horst G. Schwabe

Various known methods of producing breathable PVC leathercloth or sheeting by mechanical means without affecting the moisture vapor permeability are reviewed. Included are the use of additives, electrical methods or partial coating of the supporting fabric. A newly introduced method, the Dornair method, is described.

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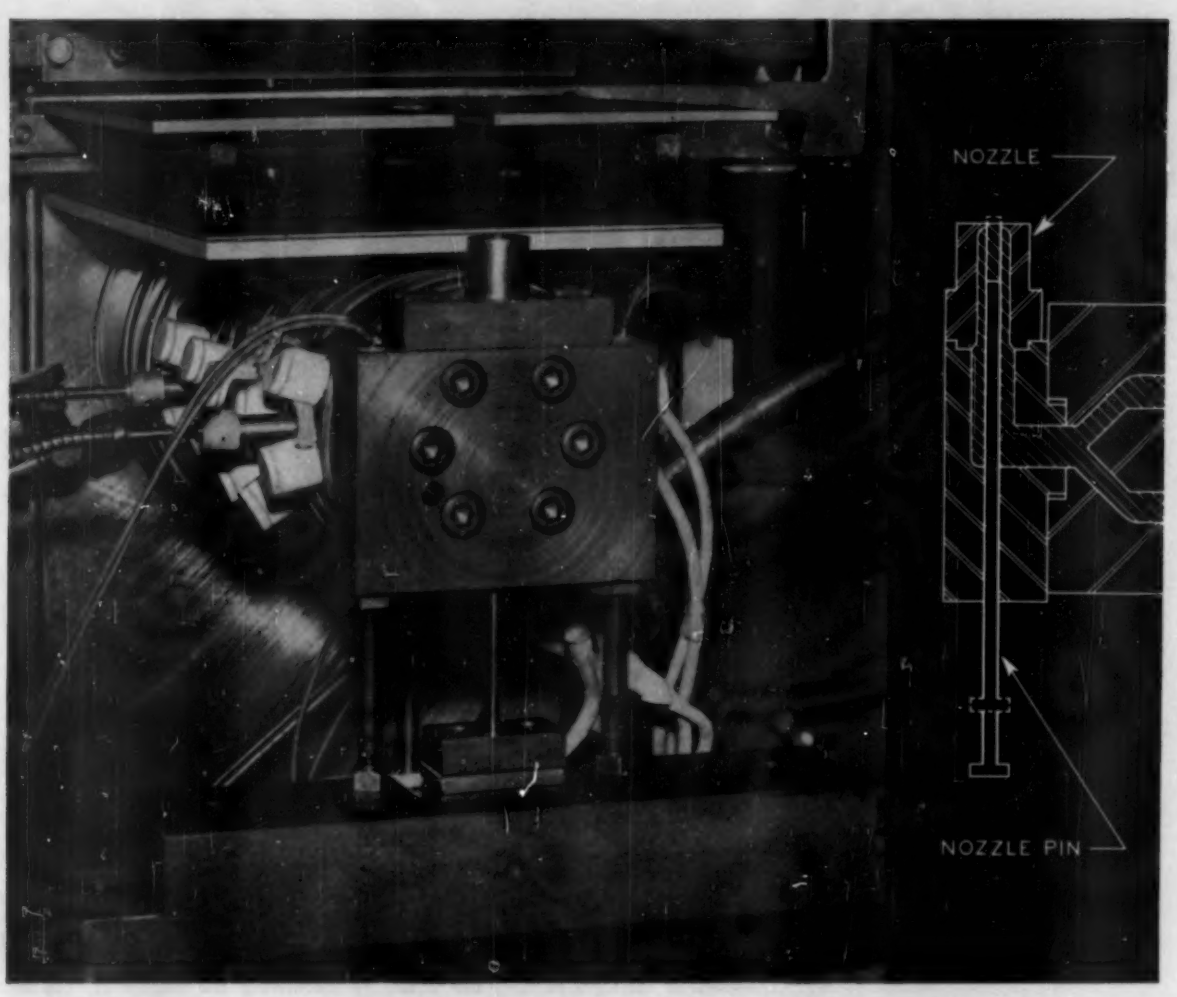

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POSITIONS WANTED

Plastics Product Development Engineer

B. S. (N. S.) major in chemistry, 14 years' diversified experience as chemist and product development engineer, materials and processes application's research in laminating, bonding, finishing, including tumbling, buffing, anodizing, electropolishing, chemical polishing. Also experience in compression and vacuum bag molding, foamed plastics, silicones, plastisols, also polyester and epoxy potting formulations. Some supervision. Experience also in sales, formulation work, manufacturing chemist, chemical analysis and physical testing. Detailed resume available. Reply Box 4858, SPE Journal, 65 Prospect St., Stamford, Conn.

★

Sales Engineer

Capable and aggressive, is seeking better opportunity in sales or management. Presently selling compression molding and preform equipment with particular experience in hydraulic and cycle control equipment. Previous wide background includes project engineering, sales promotion, sales management, and general management. Age, 39. Prefer Midwest or New England. Reply Box 4758, SPE Journal, 65 Prospect St., Stamford, Conn.

★

Senior Chemist

General background of polymeric materials, resins, plastics, rubbers and related fields, especially in research and development, with over 30 years international industrial experience. Desires connection in Europe, Germany preferred. Consulting activity would be welcome. Reply Box 4958, SPE Journal, 65 Prospect St., Stamford, Conn.

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Manufacturers Representative

Have over 8 years' experience handling plastics accounts in Washington, D.C. area. Both goverment and industry. Opening available for one additional account. Resume upon request. Reply Box 5158, SPE Journal, 65 Prospect St., Stamford, Conn.

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Sales Administration — Field Sales

Have over eighteen years' experience in marketing and sales of custom plastics. Experience equally divided between field and administrative. Seek position with materials supplier or custom molder in Connecticut but will relocate if necessary. Resume sent upon request. Reply Box 5458, SPE Journal, 65 Prospect St., Stamford, Conn.

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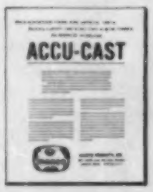

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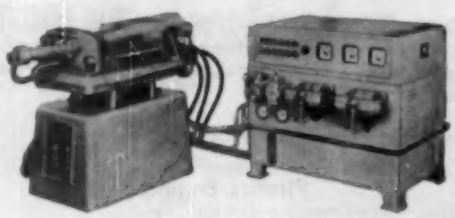

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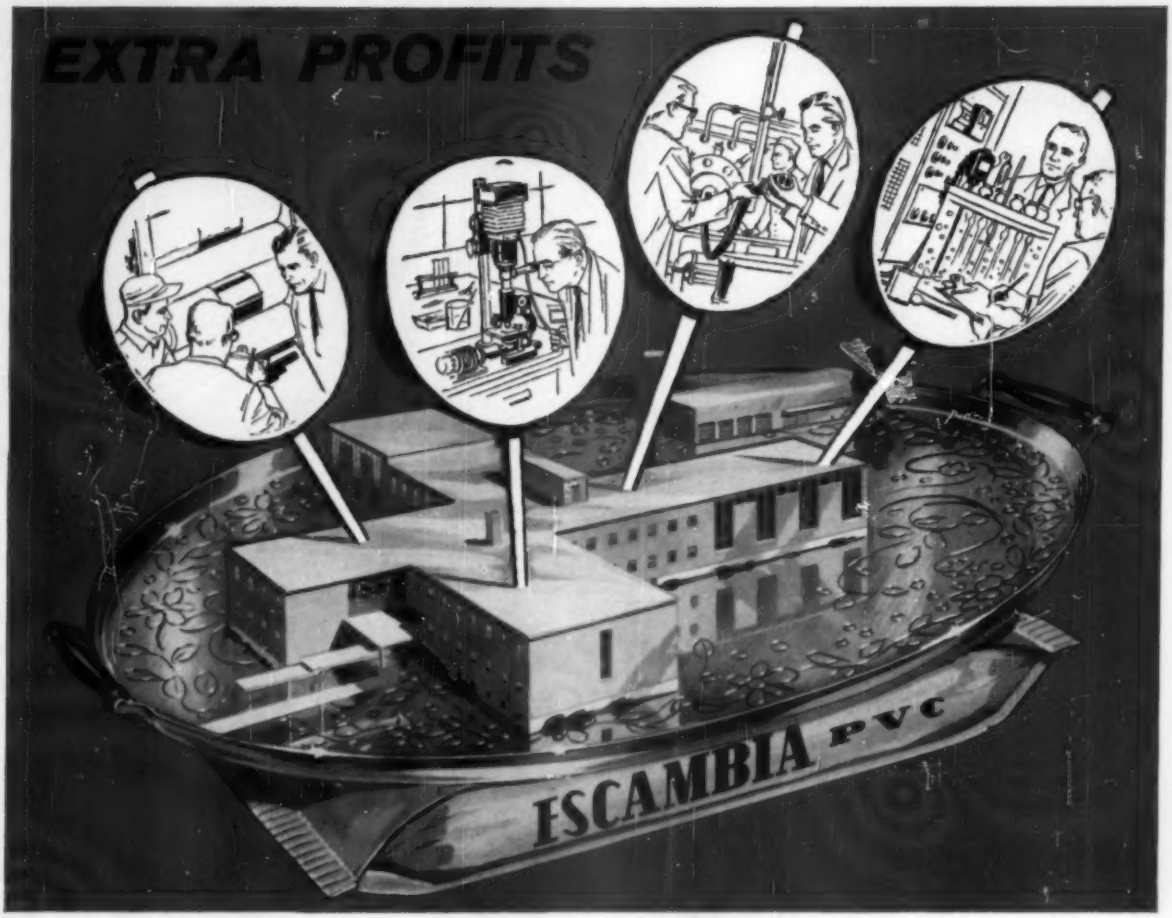

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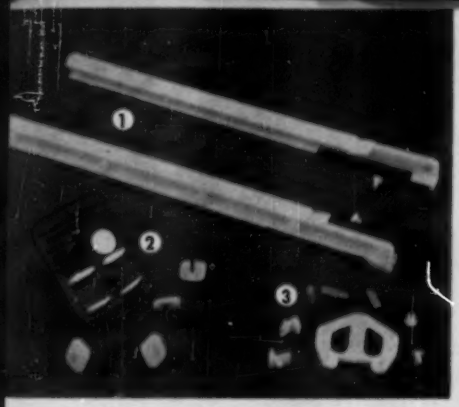

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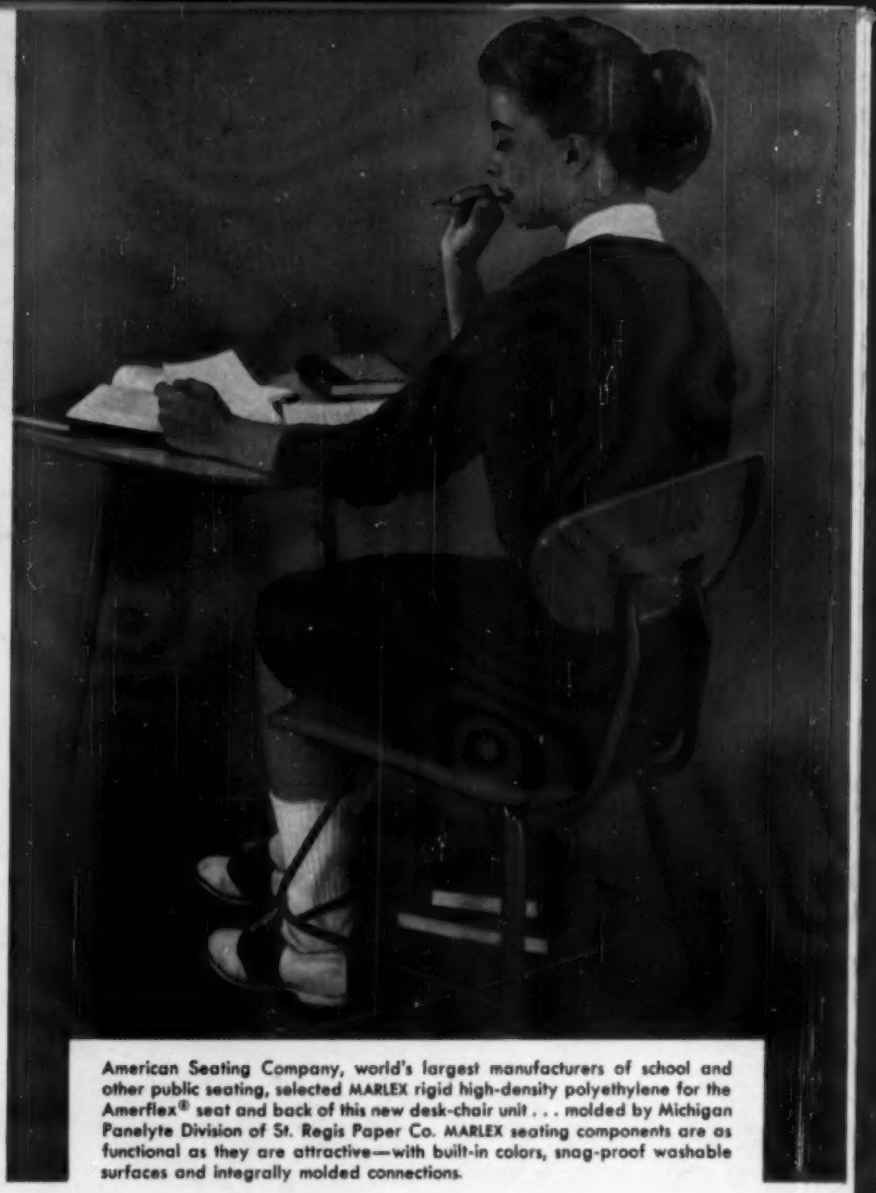

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